Second Consortium Reengineering Workshop: Approaches to Reengineering for Information Systems

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Produced by the
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PREFACE

These proceedings are based on the presentations that were made at the *Second Consortium Reengineering Workshop: Approaches to Reengineering for Information Systems*, held at the Software Productivity Consortium in Herndon, Virginia on December 4 and 5, 1995.

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1. INTRODUCTION

1.1 OVERVIEW

This document contains the results of the second Software Productivity Consortium (Consortium) Reengineering Workshop, held at the Consortium on December 4 and 5, 1995. This introduction provides general information on the workshop and a description of how the remainder of the document is organized.

1.2 WORKSHOP OBJECTIVES

The objectives of the workshop were to gather reengineering researchers and practitioners from industry and academia to discuss directions in reengineering. The workshop sought to compare approaches to reengineering information systems, including the current state-of-the-practice of reengineering of legacy systems, data and process reengineering, product lines, and object technology in reengineering.

1.3 THE WORKSHOP PROCESS

Thirty two people attended the workshop. Their names, organizations, and addresses are given in Appendix A. Attendees were invited to submit position papers prior to the workshop, make a presentation at the workshop, or both. Eight attendees submitted position statements, but one cannot be included because of copyright restrictions. Thirteen attendees made presentations.

1.4 ORGANIZATION OF THIS DOCUMENT

This document is organized as follows:

- Section 2 contains position papers submitted to the workshop.
- Section 3 contains copies of the slides presented at the workshop.
- Section 4 contains the results of the workshop.
- Appendix A contains a list of attendees.
- Appendix B contains the final workshop agenda.

1.5 TYPOGRAPHIC CONVENTIONS

This document uses the following typographic conventions:

Serif font .... General presentation of information.

Italicized serif font	Publication titles.
Boldfaced serif font	Section headings and emphasis.

2. POSITION STATEMENTS

This section contains the position statements submitted by workshop attendees. The statements are arranged alphabetically by authors' names. The following table lists the authors and the titles of their position statements (empty entries in the Title column means the authors did not supply a title for their position statement).

Shawn Bonner and Clement McGowan	Bridging the Gap Between Business Process and Software System Reengineering
Dan Juttelstad	
Julia McCreary	Reengineering Large Legacy Systems Case Study: Internal Revenue Service
Boris Mutafelija	
Anne Rose	Reengineering User Interfaces: A Case Study
Karen White	
Mark Wilson	

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(INCLUDED) I will be sending you a position statement by Nov. 30.

(INCLUDED) I am interested in making a reengineering presentation at the workshop. My topic is on: Bridging BPR and Software Systems.

Title of Presentation: Bridging The Gap Between Business Process and Software Systems Reengineering

Abstract: The bridge between business process and information systems reengineering is all too often missing from the roadmap of reengineering efforts. When process and system engineers get to this transition, they discover a rickety old bridge with steep terrain on either side of a wide chasm. Recognizing this dilemma, we developed the Business Reengineering for Information Technology (BRIT) approach that systematically transitions from business process to information systems engineering. BRIT is designed to handle a wide range of reengineering factors including: "best practices," COTS applications, non-standard business processes, and change situations ranging from continuous improvement to radical restructuring. This proven approach is described with relevant examples of its applications.

Describe your experience with reengineering projects to date.

The authors have held leadership positions in a wide range of software system reengineering efforts both in industry and the public sector. Most of the efforts over the past 5 years have been in the public sector and have focused primarily on modernizing legacy systems. The following are examples of these experiences.

The first example is a system that was originally developed in the 1960's and enhanced over twenty years. It was written in COBOL with data managed without the support of a commercial DBMS. The system was housed on an obsolete platform and software documentation was minimal. Using a combined top-down/bottom-up approach logical data models, business rules, and the like were captured and documented. These models were redeveloped for a new open systems architecture and specified for an relational database management system implementation.

The next example is a system that was originally developed as a prototype and deployed to the field in an operational environment. Without the requisite software development discipline and software documentation, software changes were difficult at best and many times impossible. Technology improvements led to platform obsolescence and ultimately the requirement that the system be modernized. Since the software was not well developed, a porting effort was not feasible. Instead, a targeted capture effort was used to identify, qualify, extract, refine/redocument, and wrap algorithms and functions determined to be useful in the new system. The rest of the project followed a more traditional development approach concentrating on a flexible architecture and reuse of the captured components.

Another example is a system that was originally developed in the late 1988's in COBOL with data managed using a hierarchical database (tuned for speed). The system was developed on an aging platform and the database architecture was deemed to be inflexible for the types of changes that the system was subject to. Using a combined top-down, bottom up approach the logical data models, business rules, and the like were captured. The database was restructured to take advantage of relational database features and redeveloped for a new open systems architecture.

What are the problems with reengineering approaches you have tried or observed?

Many of today's system modernization efforts are sparked by business process reengineering (BPR) efforts. A new process levies new requirements that the existing software system cannot support without significant changes. While new processes resulting from the BPR effort describe business level requirements, there exists a sizable gap between these requirements and the requirements needed to modernize the supporting software systems.

Approaches that have a high reliance on tool technology to reverse engineer software artifacts from source code are subject to considerable risk. Most tools advertised to accomplish software reverse engineering do not capture the requisite information needed to understand the system. Some tools are able to capture physical representations of the program and data design, but there is considerable work in transforming these representations into logical models since much of the semantic information is not conveyed in the source code.

What are you looking for in reengineering solutions, methods, and tools?

A trend that started a few years ago in the information systems engineering community was the merging of business engineering and information systems engineering concepts. We see evidence of this in CASE tools where process modeling tools are being integrated with information systems modeling tools. We are looking for integrated approaches that enable issues from both domains to be addressed.

While today's tools and methods offer some help in modeling processes and systems, technology to support reverse engineering is still lagging behind. Since information conveyed to the computer in the form of a program does not contain direct logical design or architecture information, evidence of this information must be inferred from patterns in the code and available documentation. Therefore, we should be looking for knowledge-based approaches for discovering the information necessary to reverse engineer existing systems. Just as importantly, we need to be implementing ways that new systems can be represented so that they can be readily reverse engineered in the future.

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(X) I will be sending you a position statement by Nov. 30.

( ) I am interested in making a reengineering presentation at the workshop. My topic is on: ______________________.

Position Paper

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NUWCDIVNPT Code 2253 has been addressing re-engineering of software for reuse for 4 years.
In that time a process has been developed that integrates commercial off the shelf (COTS) tools
for performing Domain Analysis, Software Assessment, Software Re-Engineering, and Software
Resuse Repository support.

The primary objective is to develop the Undersea Software Domain Reuse Repository. This
repository is intended to contain resusable software components that meet the requirments of the
undersea domain model. The software components come from existing systems software and
new development software. The components are evaluated for quality with respect to reuse and
re-engineered, if necessary, for incorporation into the reuse library.

The primary issue in performing re-engineering for reuse is the definition of metrics associated
with the re-engineering process and determing cost versus value added. It is difficult to predict
the value added by re-engineering and determineing if it is cost effective.

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Reengineering Large Legacy Systems
Case Study: Internal Revenue Service

Background

The Internal Revenue Service (IRS) story of maintaining (and attempting to replace) aging, piecemeal legacy systems is one which is familiar to many institutions. In the process of evaluating reengineering as an enabling technology, we discovered critical issues broader than the mechanical definitions of methods and tool technology. Rather, the organizational framework became the essential element; for example, identifying business objectives, performing a portfolio analysis, planning technology transition.

The IRS has been engaged in reengineering projects and studies since 1990. Three reengineering efforts were completed in Fiscal Year 1992, identifying specific IRS opportunities to utilize this technology in support of implementing Tax Systems Modernization, a massive effort planned to replace the tax systems software over a 10-year period. One project made a high-level evaluation of IRS systems to identify candidates for reengineering, based on an assessment of IRS needs and business objectives. A second project identified tools that could support the objectives identified in the first project. The third project was a prototype to demonstrate technical issues and solutions. Two smaller projects were completed in FY93, with an enterprise-wide assessment of current systems scheduled to begin in FY94. Funding for that project was postponed until FY95 and substantially reduced. Projects currently underway include a Year 2000 Project and four reuse/reengineering projects in support of new development. Throughout this period, an aggressive effort to integrate reengineering principles into the software development environment and market their benefits in light of organizational goals has met cultural as well as business challenges.

Definition

Software reengineering is defined as an enabling technology, supporting redevelopment in various strategic and tactical ways. It refers to a variety of techniques and tools employed in support of the process of using components from existing systems to improve the current system, whether that improvement includes a complete redesign and rewrite of code, a transition to a new equipment/ software platform or a simple redocumentation of current systems.

Concerns

Objective-driven

Reengineering is objective-, or goal-, oriented. There are so many applications to which the technology can be applied (platform migration, data translation, language upgrade, redocumentation) that the definition of the term is dependent upon the use being made of it in a particular application. This aspect of the "discipline" needs to be considered when creating a framework or outlining a life-cycle for redevelopment.

Cultural Barriers

The marketing of reengineering as a supporting and enabling technology for the process of software development is essential to its acceptance in the organizational culture unfamiliar with it. Organizations unfamiliar with reengineering techniques and possible benefits may resist, based on an assumption that this effort will detract from and divert resources from organizational development goals or that reengineering is counter to the "new development" efforts. These barriers must be addressed early and often They will, no doubt, continue to be a part of the environment into which reengineering will be integrated. Management support, once garnered, can be essential in keeping the momentum going against cultural resistance.

Transition Issues

Transition and the orderly retirement and replacement of legacy systems with newly developed or redeveloped systems is one of the most critical issues facing the IRS today. Most replacement scenarios do not have a clean one-to-one mapping of functions and data to the systems they are replacing. The management of identifying functions and preparing the systems and data being replaced is a part of the reengineering discipline that is essential to a successful Tax Systems Modernization effort.

Conclusions

It has been said by many, but the essential ingredients to successful implementation of an enabling technology like reengineering are organizational. Organizational needs must be identified and assessed. Clearly, not every organization requires every technical solution available through reengineering. A supportive management group must be identified. A SMALL pilot project which will result in a production solution to a real problem, and has a high likelihood of success, needs to be identified and recognized. The results of that project need to be publicized, using that success to integrate reengineering in the software development process elsewhere in the organization. And when the pilot is not a success, or the organization changes direction, rendering the transition plans out-of-step, the organizational needs must be revisited to bring the reengineering solutions to bear on those with a good return-on-investment. Recent industry "hype" has resulted in high expectations being held by management, followed by disappointment and a sense that the technology has "nothing useful to offer" . A plan should be developed for implementing those aspects of reengineering that are sensible for the organization, based on recognized business goals and reasonable supporting technology.

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Gerry,

As per your announcement please register me for the 2nd SPC Reengineering Workshop.

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Attached below is my "Position Statement".

Northrop Grumman Data Systems and Services Division External Information Systems Business Unit is extending its standard organizational software process to include reuse and reengineering. We often encounter requirements to reengineer a large body of legacy software and transition this reengineered software into a solution required by the customer. Typically, our customers require that reengineered systems satisfy additional requirements, such as enhancements to existing software, integration of reengineered legacy systems with new applications (frequently COTS software), etc.

Problems that we experience can be classified as:

1 - System engineering problems

? development of complete solutions that will include reengineered legacy software, newly developed software, and COTS software (forward- and re-engineering combined)
? addition of new capabilities, including increased reliability, maintainability, transportability
? process/methodology addressing multistep reengineering (i.e. reengineering that covers code conversion, data conversion, database conversion, rehosting, adding new capabilities, etc.)
? integration of reengineered legacy code with COTS software
? testing strategies

? transitioning (to a new system)

2 - Reengineering problems

? reengineer vs. reverse engineer vs. restructure: when is each one appropriate? how do they play together?
? reengineer and enhance (there are additional requirements to be satisfied)
? convert from one language (most frequently COBOL) to another (most frequently Ada)
? convert from hierarchical to relational database
? convert from mainframe to client-server; in addition, convert code from one language to another, and from one database format to another (multistep reengineering)

3 - Implementation problems

? system analysis/synthesis tools
? need for tool repositories
? system testing tools
? reengineering tools (rehosting, translating, conversion)

What we are looking for in reengineering solutions, methods and tools:

? reengineering process definition (hopefully related to ESP or GSEP)
? methodology for analyzing and synthesizing systems that contain reengineered legacy systems, have additional requirements, and may include COTS software (in order to satisfy all new requirements)
? reengineering taxonomy (classification) and implementation of such taxonomy to practical problems (similar to E. Chikofsky s paper in IEEE Software)
? development of test strategies (including test case generation) for such systems
? tools for analyzing, synthesizing and then testing such systems (forward- and re-engineering tools integrated into one tool-set (through a repository?))

? Project management aspects:
   ? estimation
   ? planning and scheduling
   ? controlling
   ? quality assurance and configuration management

? Process engineering aspects
   ? process descriptions
   ? life-cycle selection (waterfall, incremental, evolutionary)
   ? reengineering risk analysis (similar to R. Arnold s paper)

? Effectiveness
   ? cost/benefit models for each reengineering approach (e.g. conversion, reverse engineering, rehosting, mixture)
   ? when NOT to reengineer?

Re-engineering User Interfaces: A Case Study

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November 29, 1995

The Human-Computer Interaction Laboratory (HCIL) is currently under contract with the Maryland Department of Juvenile Justice (DJJ) to make recommendations for redesigning the user interface of their information system, ISYS. ISYS, Information System for Youth Services, is a terminal based system used to support the case processing of approximately 50,000 referrals of delinquent youth behavior. It is built around a centralized IDMS database that is running on an IBM mainframe located at the Annapolis Data Center. ISYS is used by about 600 DJJ employees in various offices and facilities across the state.

During our first year, we evaluated ISYS, proposed short term recommendations, and developed prototypes for NISYS, the next generation ISYS. We employed several techniques to learn, assess, and evaluate, ISYS including reading the documentation, performing 22 field visits, attending training sessions, getting our own hands-on experience, and administering the Questionnaire for User Interaction Satisfaction (QUIS) [2][6]. QUIS was developed by the HCIL to quantitatively evaluate the strengths and weaknesses of user interfaces. In consultation with DJJ, the QUIS was tailored to address specific issues of concern to DJJ and administered to 332 employees. The mean rating for ISYS, out of 9, was 5.1.

The field visits provided us with valuable insight about ISYS, and about the functioning of DJJ in general. A typical visit consisted of an overview from a supervisor, observing users performing routine tasks, and discussing what they liked and disliked. We refined our observation techniques and proposed an applied ethnographic method for redesigning user interfaces [5].

Based on our findings, we proposed 28 short term recommendations to improve the ISYS interface while NISYS is being developed. Our recommendations focused on:

- making system access easier,
- improving data accuracy,
- making information retrieval easier,
- increasing the usefulness of the system, and
- improving user satisfaction.

We provided a rough estimate of the payoff vs. the implementation cost for each recommendation. DJJ's initial response was to take action on all 28 recommendations. However, because of internal restructuring only a few recommendations have been implemented to date.

We also proposed three NISYS prototypes in response to the needs discovered during the evaluation:

- LifeLines, which uses time lines to display a youth's history with DJJ on one screen [4],
- the DJJ Navigator, which helps manage individual workloads by displaying different user views, and
- the Information Visualization & Exploration Environment (IVEE)[1], a generic tool that can be used to visualize, explore, and make queries on DJJ datasets [1].

We demonstrated these prototypes to 60 DJJ personnel and made revisions based on their comments. Overall, their feedback was very positive. One challenge we have found is how to get constructive feedback. For many DJJ employees, ISYS is their only computer experience so they find it difficult to provide constructive criticism. They seem to like our prototypes too quickly simply because it looks better than what they have now. Providing rough sketches, that don't look like finished applications, or providing alternative designs, might be the solution.

We have also been working with Cognetics, Corp., our subcontractor, who is working in conjunction with DJJ, to prepare the request for proposal (RFP) for NISYS. The Cognetics Design Methodology (CDM) is being used for this process [3]. We are currently working on the functional requirements. The NISYS project is serving as an exercise to test the practicality of CDM. CDM is being modified as new needs are discovered.

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[1] Ahlberg, C., Wistrand, E., IVEE: An Information and Visualization & Exploration Environment, *Proceedings of IEEE Visualization '95 (Atlanta, Georgia, October 1995)*, 66-73.

[2] Chin, J., Diehl, V., and Norman, K., (1988), "Development of an instrument measuring user satisfaction of the human–computer interface", *Proceedings of CHI'88—Human Factors in Computing Systems*, ACM, New York, 213–218.

[3] Kreitzburg, C., (1995), "Managing for Usability: The Cognetics Design Methodology", Cognetics, Corp., Princeton Junction, NJ.

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[6] Vanniamparampil, A., Shneiderman, B., Plaisant, C., and Rose, A., (1995), "User Interface Reengineering: A Diagnostic Approach", CAR-TR-3459, University of Maryland, College Park, MD.

[1] IVEE was developed by Christopher Ahlberg and Erik Wistrand of Chalmers University, Sweden. It is based on earlier research by HCIL. URL: http://www.cs.chalmers.se/SSKKII/ivee.html

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( ) I will be sending you a position statement by Nov. 30.

POSITION STATEMENT IS INCLUDED BELOW.

( ) I am interested in making a reengineering presentation at the workshop. My topic is on:

POSITION STATEMENT:

I have been involved with the enhancement and maintenance of so-called legacy software systems for the past 17 years. During that time I have seen systems translated from one language to another, re-structured to provide better performance, and completely re-built. Within the immediate past history, I have participated in efforts that ranged from the reengineering/re-hosting of a user interface associated with a legacy system, to the development of a strategic plan for

Registration for SPC Reengineering Wkshp (fwd)   11/27/95 8:44:59 AM

reengineering of an application, to the reengineering of a "mission critical" (but not embedded!) system.

The problems we encountered were primarily associated with the "reverse engineering" activities and managing the user's expectations about the final product. The project management (both customer & user) held the assumption that one can successfully reengineer an application by analysing only the existing software, a piece at a time. We failed in conveying to them the benefit associated with having the current support staff participate in the reengineering project. (It should be noted that support of the legacy system was provided by another contractor & that they were the users of the new system; the customer was a DoD dept.) A comprehensive reverse engineering project, including development of models of the undocumented legacy system, should have been completed before we started the forward engineering; there would have been fewer surprises at the end. Or, the project should have been treated as a "scrap the old & let's build a new from scratch" with a full-blown requirements analysis phase.

My interests are:
(1) Approaches to reengineering user interfaces INDEPENDENT of the rest of the application;
(2) Connecting business process modelling, reverse engineering and forward engineering. What methods exist (don't exist) that allows a business manager to see in a straightforward fashion how the current system does or does not support the business process and how the proposed system will.
(3) Management of a reengineering project; how does one identify the risk areas, does one break the project up into reverse engineering projects and then forward engineering projects; how does COTS integration "mess up" the picture; where are the logical milestones for "go, no-go" decisions

UNIVERSITY OF MARYLAND AT COLLEGE PARK

OFFICE OF TECHNOLOGY LIAISON ♦ GRADUATE STUDIES AND RESEARCH

QUESTIONNAIRE FOR USER INTERACTION SATISFACTION ("QUIS™")

The most powerful computer is a computer which people will use; similarly, software programs must meet the approval of the end user to be effective. Measuring and understanding user reactions to computer software is important to many who are creating new services and programs, evaluating older versions, or making choices between similar products for certain applications. While the evaluation of a system's accuracy is fairly straightforward, the assessment of the user's satisfaction with the human-computer interface is a subjective and complex question.

A multi-disciplinary team of researchers at the University of Maryland at College Park (UMCP) has developed an instrument which evaluates user satisfaction with the human-computer interface aspect of other software packages and computer systems. The Questionnaire for User Interaction Satisfaction ("QUIS™") includes a paper version as well as a computerized questionnaire which assesses users' attitudes and subjective satisfaction with a system, especially the users' evaluation of the human-computer interface. "Although a system may be evaluated favorably on every performance measure, the new system may not be used very much if the user is dissatisfied with the system and its interface," said Dr. Kent L. Norman of the UMCP Department of Psychology and the Human-Computer Interaction Laboratory (HCIL).

The QUIS™ covers four major areas: Screen, Terminology and System Information, Learning, and System Capabilities. Within each area, several issues are rated on a nine-point scale, with guides such as Barely Legible...Very Legible; Confusing...Clear; Difficult...Easy; Complex...Simple. The wide range of topics includes the computer's noise level, helpfulness of reference materials, even screen sequencing. The user is able to rate any computer program using QUIS™, thus producing a reliable evaluation of the interactive workstation. According to Dr. Benjamin Shneiderman of the Computer Science Department and Director of the HCIL, "The QUIS™ does two things. It taps the overall subjective reaction of a user to an on-line computer system, and it is a diagnostic of the strengths and weaknesses of a system. It assesses such things as satisfaction with the display of graphics, readability, reliability, understandability, and other features." Please see reverse for additional specifications.

The QUIS™: Questionnaire for User Interaction Satisfaction

Developed in the Human/Computer Interaction Laboratory at the University of Maryland by Kent Norman and Ben Shneiderman, the QUIS™ is one of the only instruments for assessing user evaluations of interactive workstations that has proven reliability and validity. It has been standardized over a number of applications and research studies. It is now being used in the field by a number of usability and research labs in both government and industry.

The QUIS™ assesses 6 factors of overall reactions to the system and 21 components that contribute to usability. The QUIS™ can be used in its current form or modified to meet particular research needs.

The QUIS™ is available in a paper version and two on-line versions (a Windows™ version and a Macintosh™ Spinnaker Plus™ version).

QUIS™ Site License Information

A site license for commercial use of the QUIS™ is now available for $750. A reduced fee ($200) is available for academic/non-profit use. The licensing package includes the following:

- Two copies of the QUIS™ paper version with the right to make an unlimited number of copies for use at one site.
- Copies of all HCIL publications pertaining to the use of the QUIS™.
- The Windows™ version of the QUIS™ on a 3.5 inch floppy disk with the right to use copies at your site.
- The Macintosh™ Spinnaker Plus™ stackware version of the QUIS™ on a 3.5 inch disk with the right to use copies at your site.
- Run-time versions of Macintosh Spinnaker Plus.

The site license gives authorization for unlimited use of the QUIS™ at one site. You may copy the entirety of the questionnaire, parts of it, or revise it for use in evaluation of commercial software/hardware for usability testing, research, and development.

For technical information on the QUIS™, contact:

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Systems Reengineering
Position Paper
for
Second SPC Reengineering Workshop

Mark L. Wilson

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We, in the Navy tactical community, are concerned primarily with real-time, safety critical, mission critical, complex systems. Many of these systems are written in CMS-2 programming language with at least some and often substantial amounts of assembly code. They run on Navy military standard computers such as UYK-7, UYK-43, UYK-20, UYK-44, and AYK-14.

Most of these systems were designed with memory or other architectural constraints which no longer apply. Thus thorough reengineering requires consideration of the design rationale which may not be explicit in the existing documentation. Moreover, there may be timing or other relationships which only become apparent during the most thorough system test.

Driving factors for reengineering may include a desire to: avoid hardware obsolescence, increase performance to accommodate new or enhanced requirements, reduce software maintenance costs, reduce hardware procurement costs, reduce maintenance costs, and take advantage of current software design practices and tools. In essence the goal is rehosting or retargeting to improve performance, reduce cost, and reduce development time. A secondary goal is to try, where practical, to further reduce cost and development time through reuse.

One of our short term goals is the ability to efficiently transform highly hardware dependent legacy systems into moderately hardware independent open systems. Our long term goal is the ability to effectively transform complex legacy systems into systems that can evolve gracefully over time. Evolution will typically involve increased requirements, new processor hardware, new display technologies, and integration with additional systems. It may also involve reuse within or across systems and domains, totally new requirements unanticipated during design, partition into parallel or distributed architectures, combination into fewer more powerful processors, new human computer interfaces, networks to replace point-to-point communication, or translation from one language into another.

Some of the techniques we see as useful are a layered approach to system and software design, automatic or semiautomatic language translation, and graphical aids to software and system understanding. It may also be useful to have econometric models to guide the decisions of when and how to reengineer.

We at NSWC have addressed a number of these issues. Among them we have helped develop and test CMS-2 to Ada translation tools, an Assembler to CMS-2 translator, graphical aids to software understanding, and have worked on populating several domains with legacy components. Most of this work was funded by ONR, some by SBIRs, and some by the JLC/CRM/RRFWG. We also organized and sponsored a series of Systems Reengineering Technology Workshops - the last two of which were held in Monterey, California; and a Reengineering Focus Group at the First and Second Workshop on Engineering Systems in the Twenty-First Century (WES21).

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3. SLIDES PRESENTED

This section contains copies of the slides used in presentations at the workshop. The slides are arranged in chronological order (see Appendix B).

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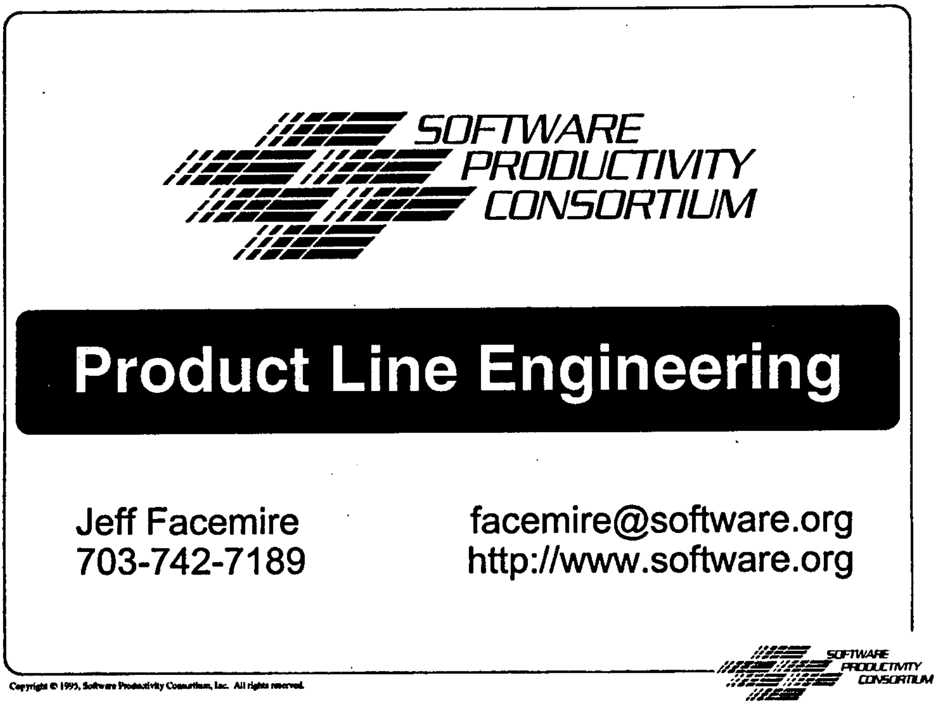

SOFTWARE
PRODUCTIVITY
CONSORTIUM

Product Line Engineering

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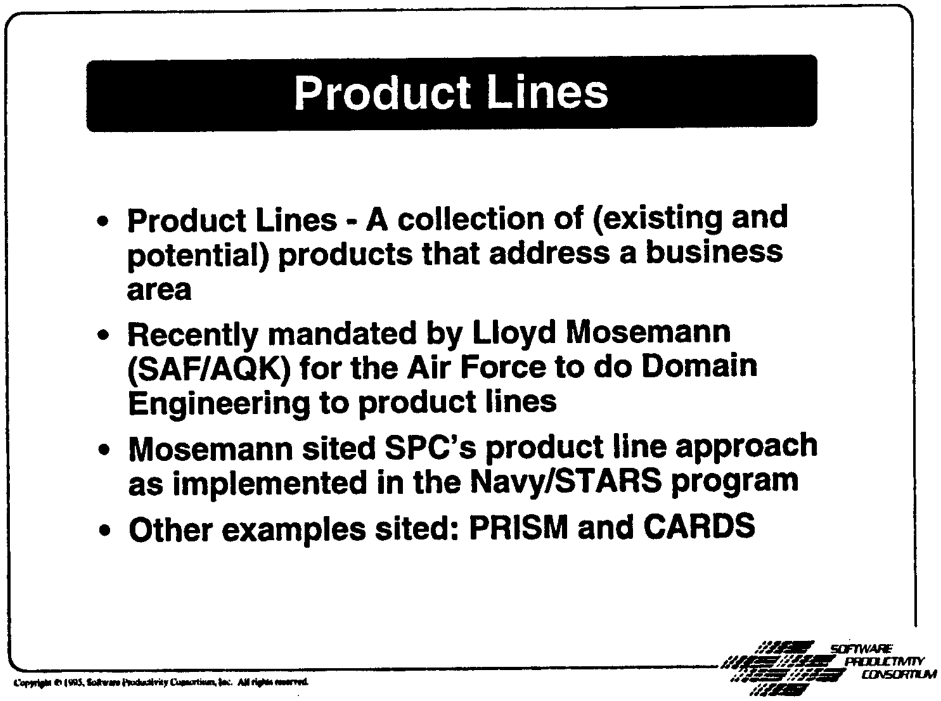
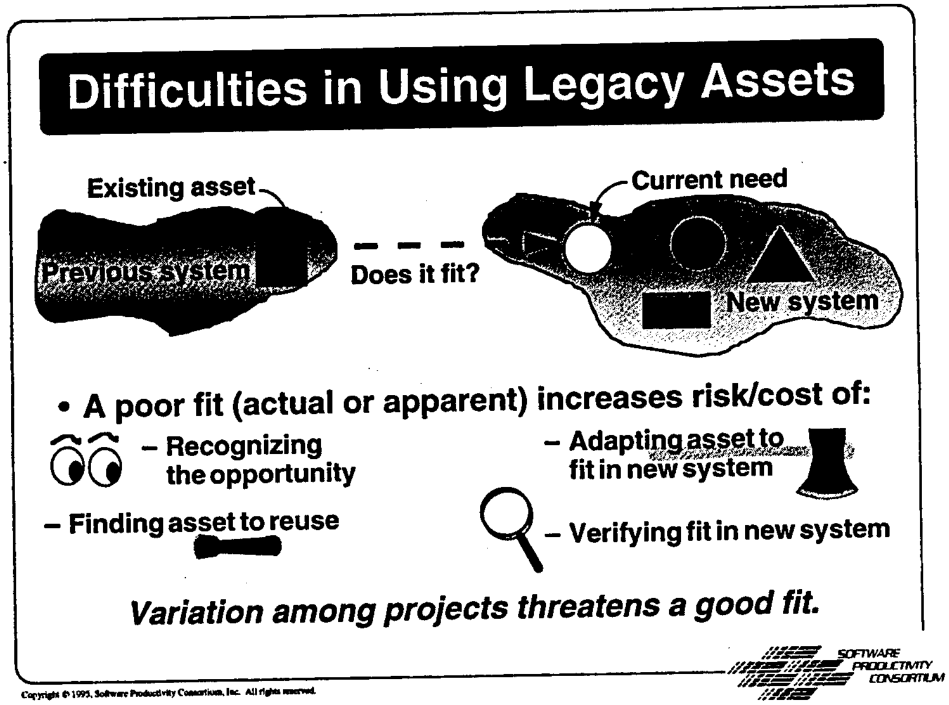
SOFTWARE
PRODUCTIVITY
CONSORTIUM



Product Lines

- Product Lines - A collection of (existing and potential) products that address a business area
- Recently mandated by Lloyd Mosemann (SAF/AQK) for the Air Force to do Domain Engineering to product lines
- Mosemann sited SPC's product line approach as implemented in the Navy/STARS program
- Other examples sited: PRISM and CARDS

SOFTWARE
PRODUCTIVITY
CONSORTIUM



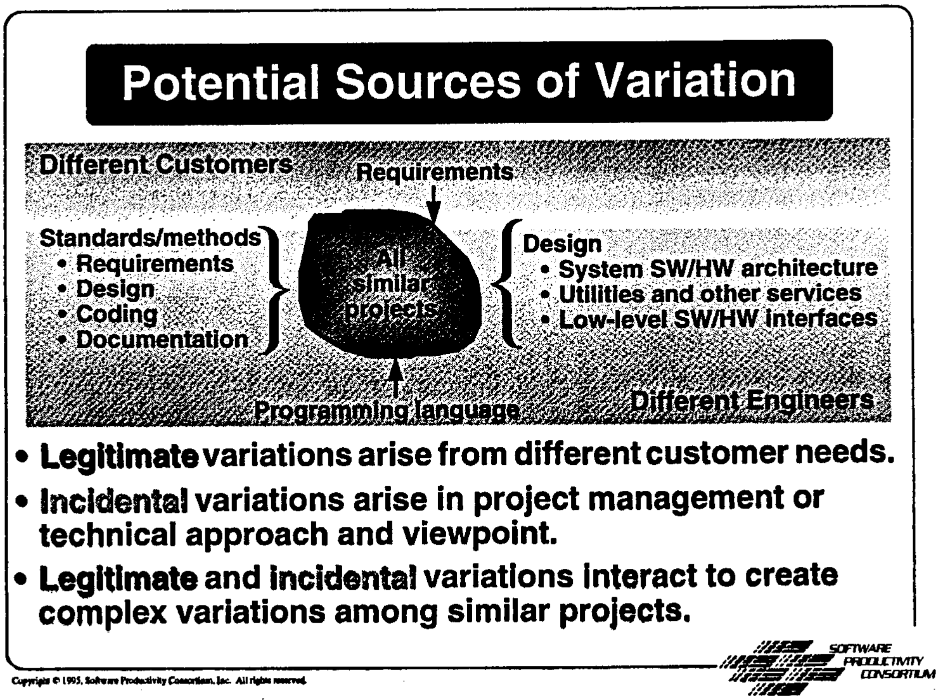
Difficulties in Using Legacy Assets

Existing asset
Previous system
Does it fit?
Current need
New system

- A poor fit (actual or apparent) increases risk/cost of:
  - – Recognizing the opportunity
  - – Finding asset to reuse
  - – Adapting asset to fit in new system
  - – Verifying fit in new system

Variation among projects threatens a good fit.

SOFTWARE PRODUCTIVITY CONSORTIUM

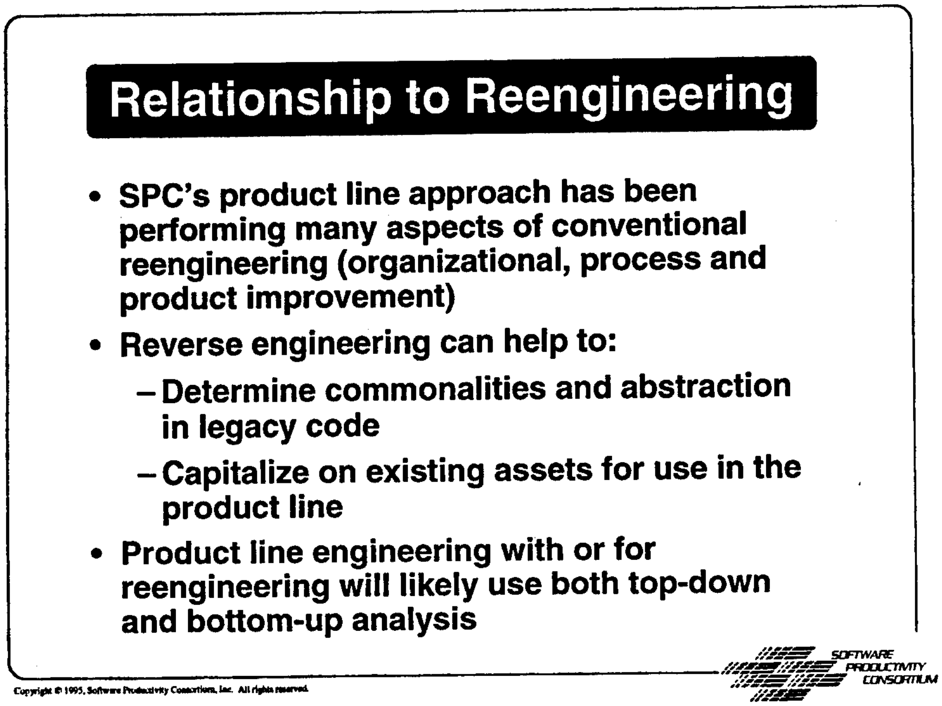


Potential Sources of Variation

Different Customers
Requirements
Standards/methods
• Requirements
• Design
• Coding
• Documentation
All similar projects
Design
• System SW/HW architecture
• Utilities and other services
• Low-level SW/HW interfaces
Programming language
Different Engineers

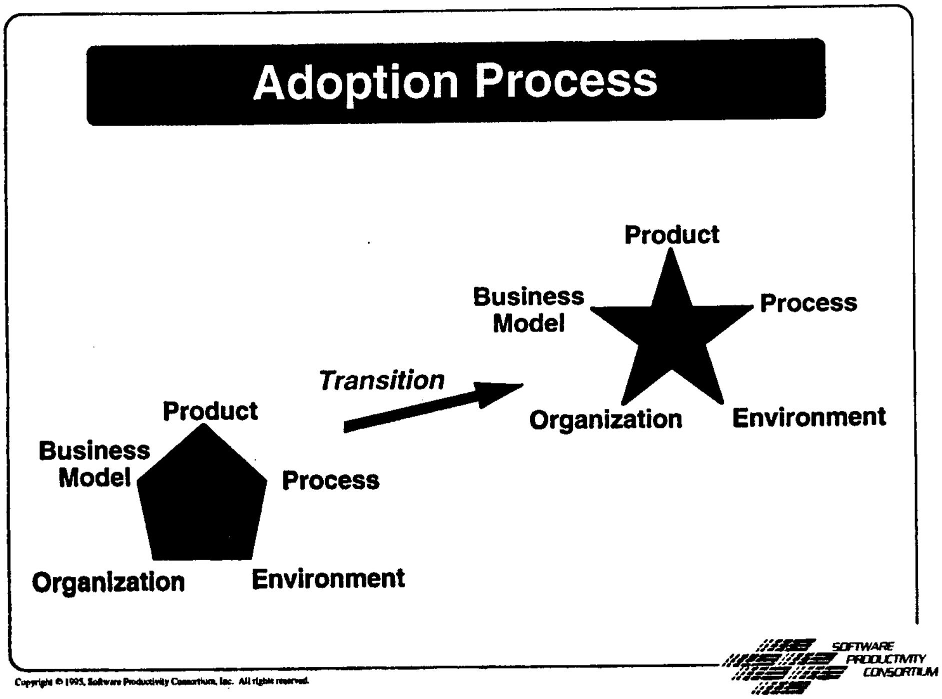
- **Legitimate** variations arise from different customer needs.
- **Incidental** variations arise in project management or technical approach and viewpoint.
- **Legitimate** and **incidental** variations interact to create complex variations among similar projects.

SOFTWARE PRODUCTIVITY CONSORTIUM

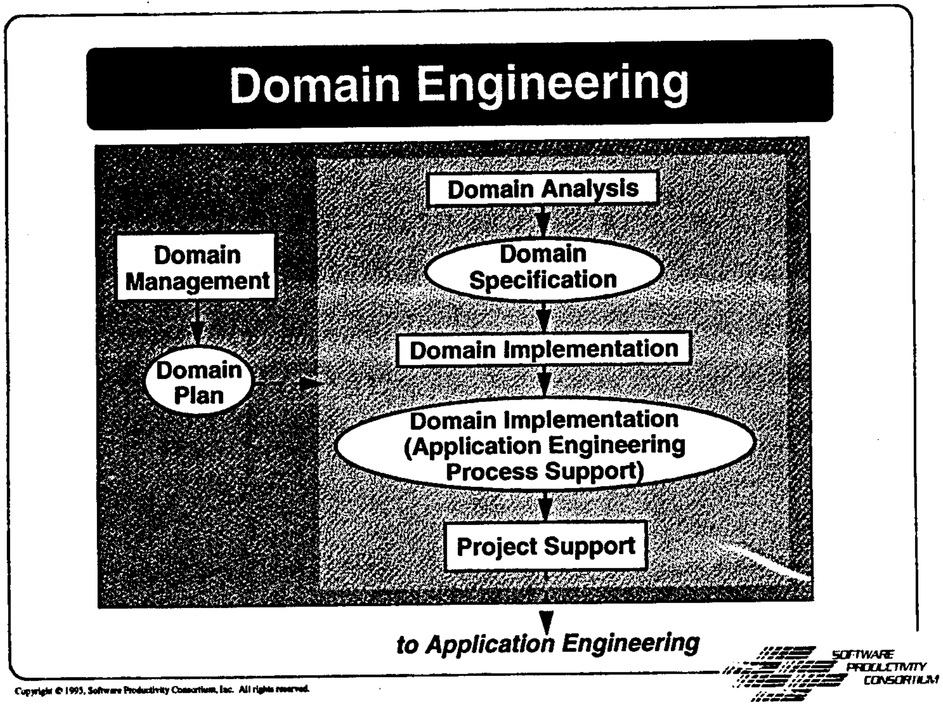


Relationship to Reengineering

- SPC's product line approach has been performing many aspects of conventional reengineering (organizational, process and product improvement)
- Reverse engineering can help to:
  - Determine commonalities and abstraction in legacy code
  - Capitalize on existing assets for use in the product line
- Product line engineering with or for reengineering will likely use both top-down and bottom-up analysis



Adoption Process



Domain Engineering

Domain Management

Domain Plan

Domain Analysis

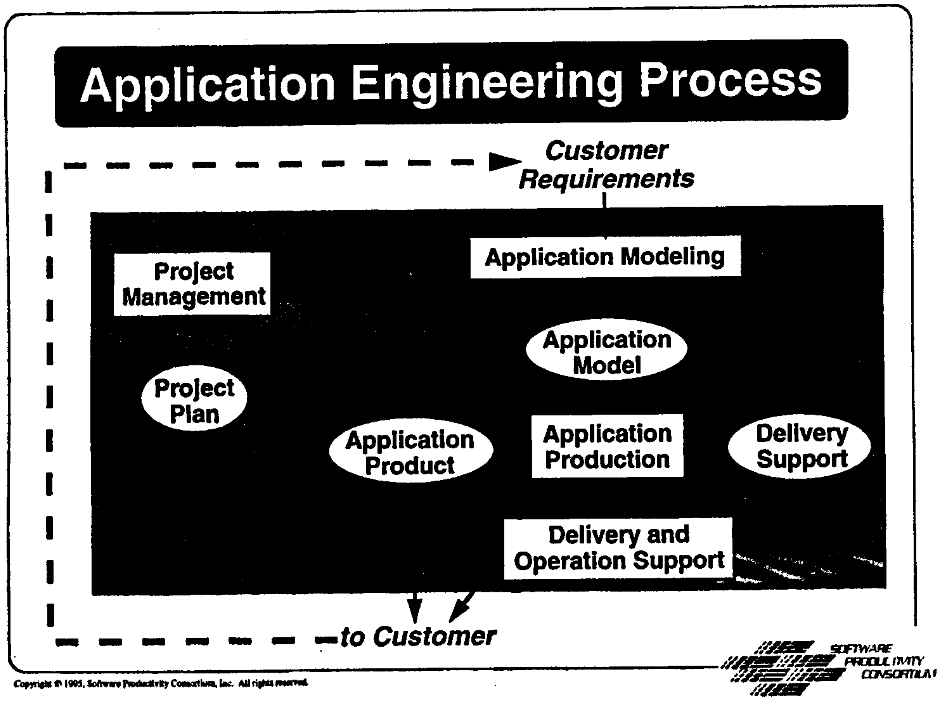
Domain Specification

Domain Implementation

Domain Implementation (Application Engineering Process Support)

Project Support

to Application Engineering



Application Engineering Process

Customer Requirements

Project Management

Project Plan

Application Modeling

Application Model

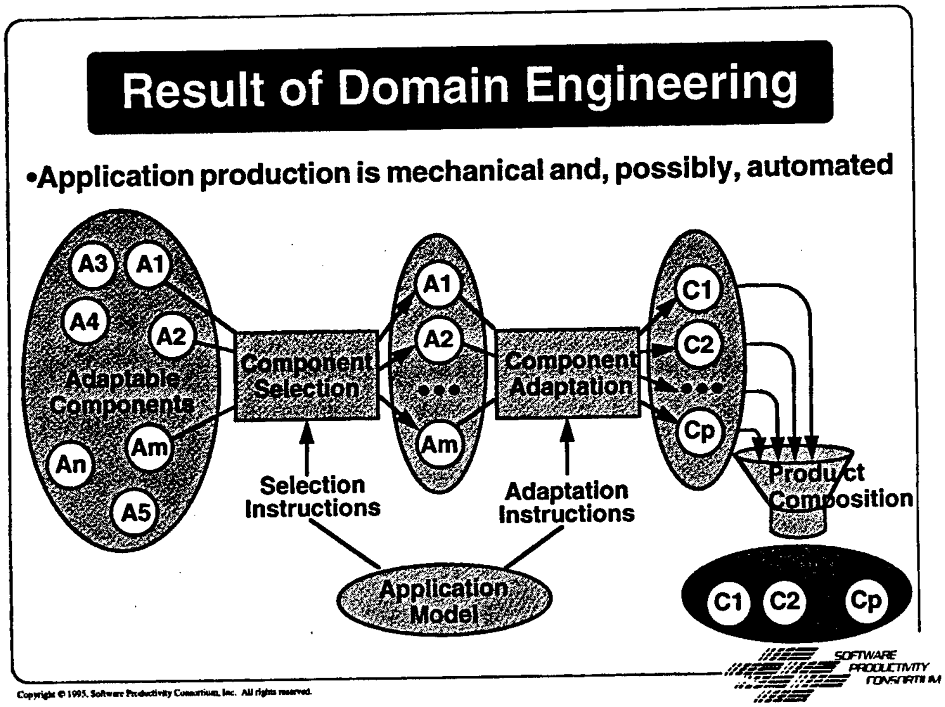
Application Product

Application Production

Delivery Support

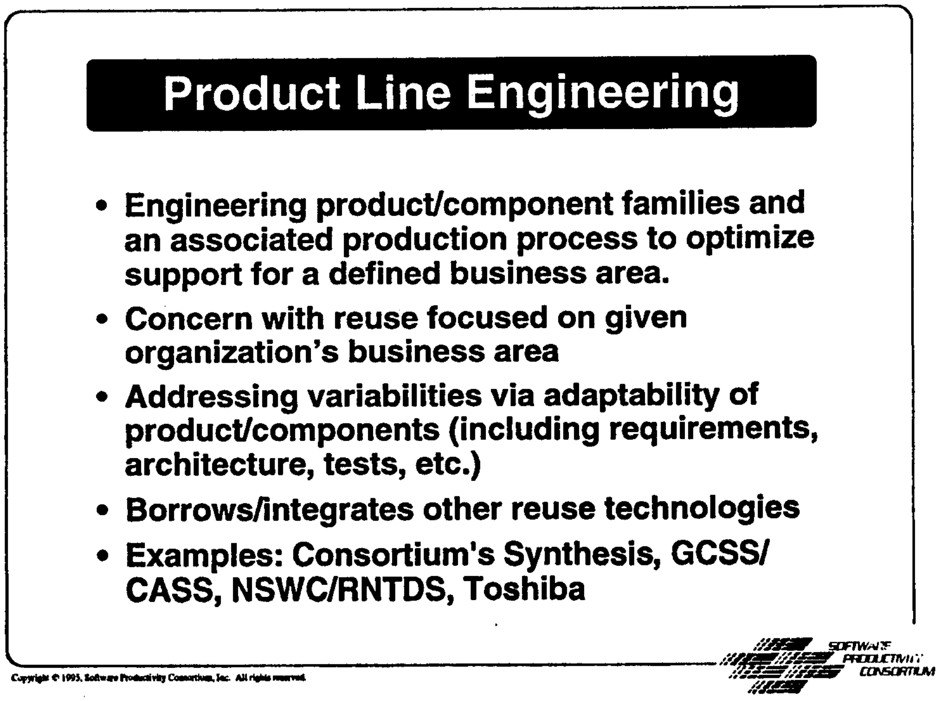
Delivery and Operation Support

to Customer



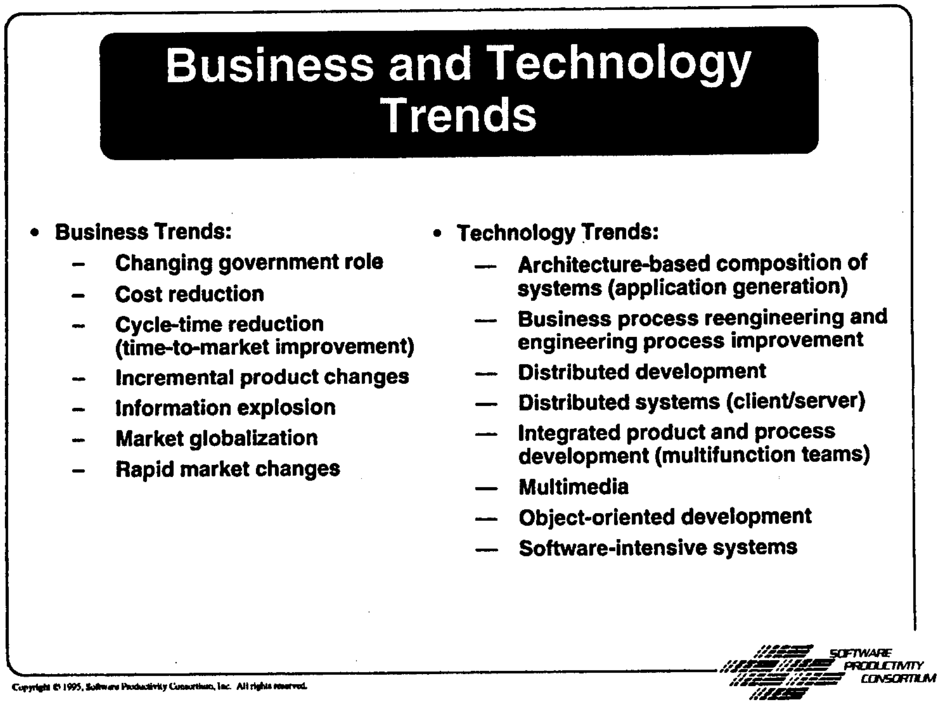
Result of Domain Engineering

- Application production is mechanical and, possibly, automated



Product Line Engineering

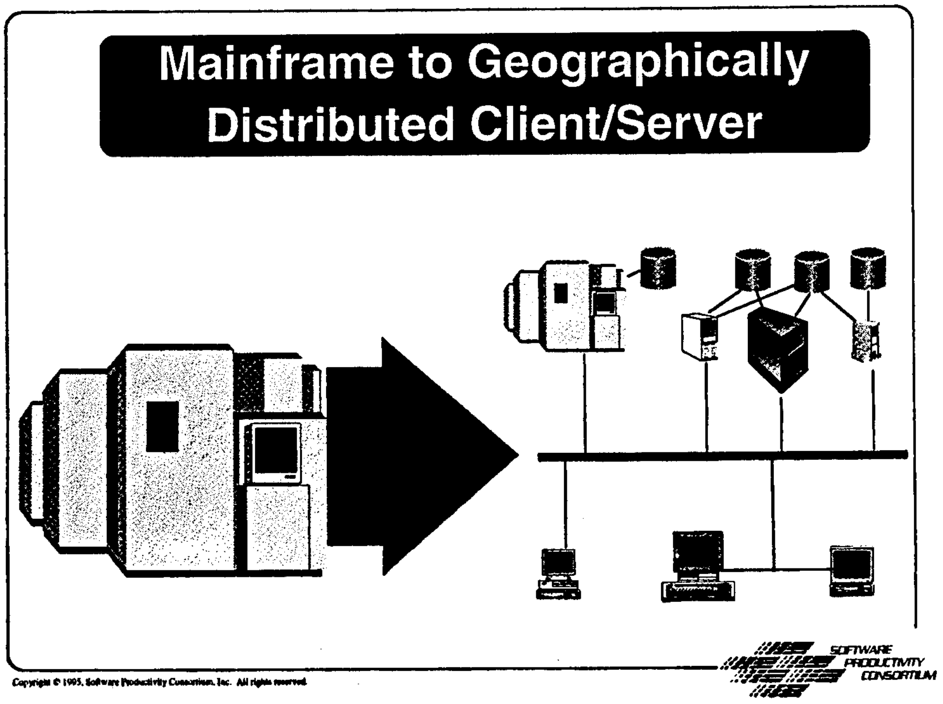
- Engineering product/component families and an associated production process to optimize support for a defined business area.
- Concern with reuse focused on given organization’s business area
- Addressing variabilities via adaptability of product/components (including requirements, architecture, tests, etc.)
- Borrows/integrates other reuse technologies
- Examples: Consortium's Synthesis, GCSS/ CASS, NSWC/RNTDS, Toshiba



Business and Technology Trends

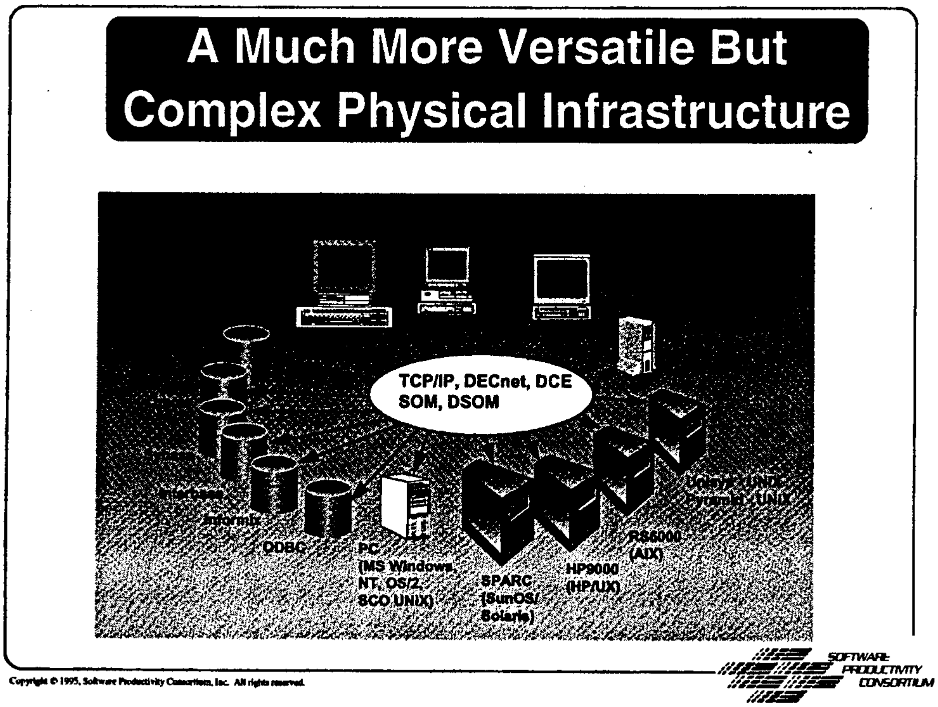
- Business Trends:
  - Changing government role
  - Cost reduction
  - Cycle-time reduction (time-to-market improvement)
  - Incremental product changes
  - Information explosion
  - Market globalization
  - Rapid market changes
- Technology Trends:
  - Architecture-based composition of systems (application generation)
  - Business process reengineering and engineering process improvement
  - Distributed development
  - Distributed systems (client/server)
  - Integrated product and process development (multifunction teams)
  - Multimedia
  - Object-oriented development
  - Software-intensive systems

SOFTWARE PRODUCTIVITY CONSORTIUM

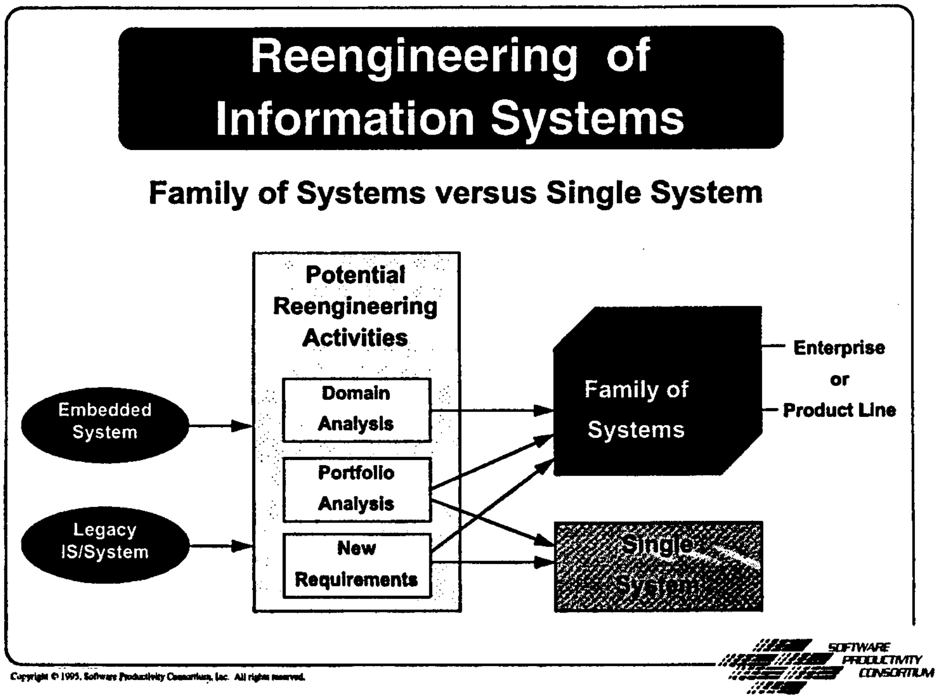


Mainframe to Geographically Distributed Client/Server

SOFTWARE PRODUCTIVITY CONSORTIUM



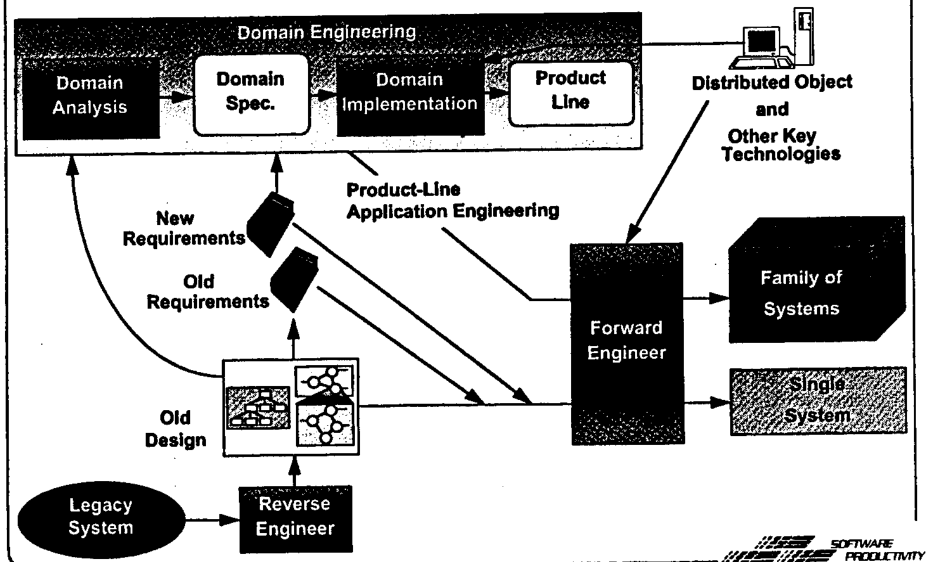
A Much More Versatile But Complex Physical Infrastructure



Reengineering of Information Systems

Family of Systems versus Single System

Domain-Based Reengineering



Domain Engineering

Domain Analysis

Domain Spec.

Domain Implementation

Product Line

Distributed Object and Other Key Technologies

Product-Line Application Engineering

New Requirements

Old Requirements

Old Design

Forward Engineer

Family of Systems

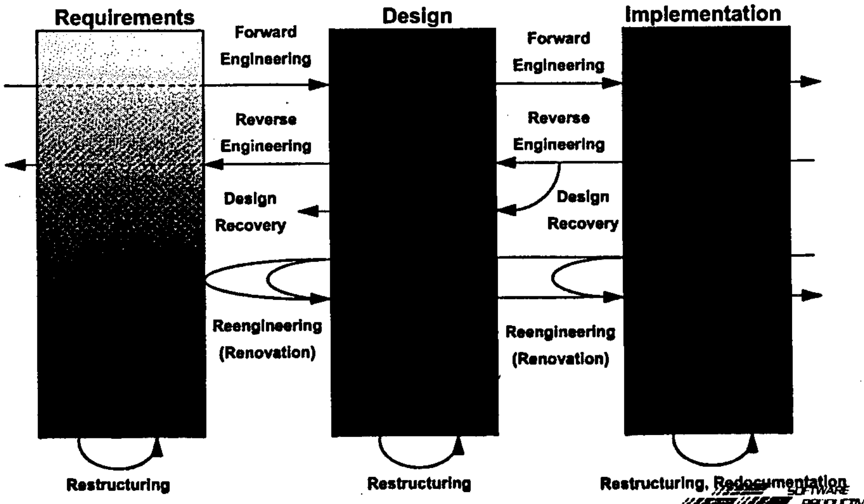
Single System

Legacy System

Reverse Engineer

SOFTWARE PRODUCTIVITY CONSORTIUM

De Facto Reengineering Taxonomy



Requirements

Design

Implementation

Forward Engineering

Forward Engineering

Reverse Engineering

Reverse Engineering

Design Recovery

Design Recovery

Reengineering (Renovation)

Reengineering (Renovation)

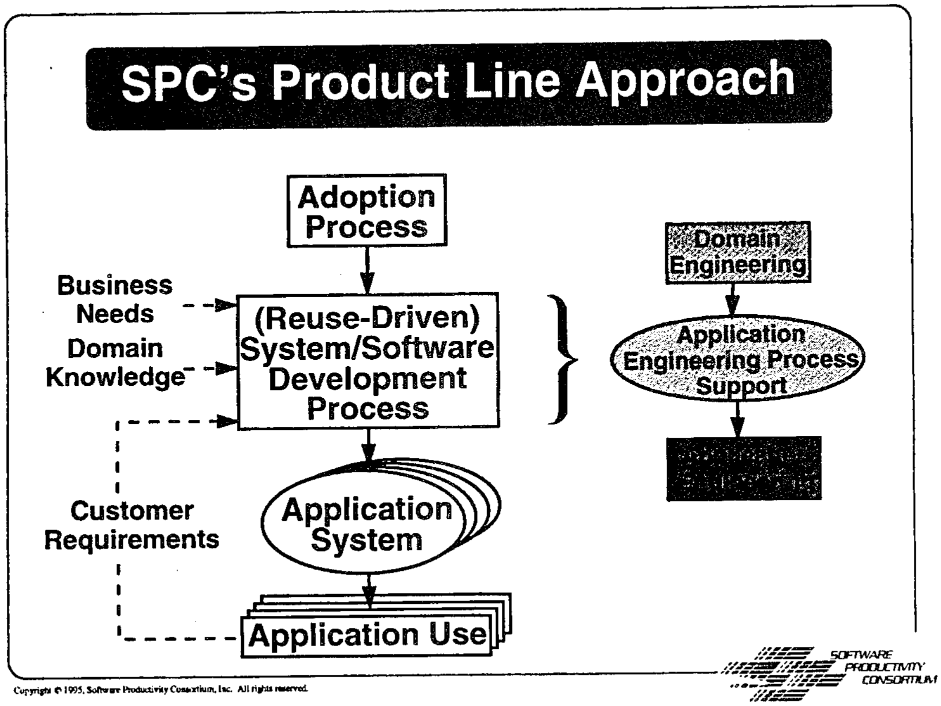
Restructuring

Restructuring

Restructuring, Redocumentation

Source: Chikofsky and Cross (1990)

SOFTWARE PRODUCTIVITY CONSORTIUM



SPC's Product Line Approach

Adoption Process

Business Needs

Domain Knowledge

(Reuse-Driven) System/Software Development Process

Customer Requirements

Application System

Application Use

Domain Engineering

Application Engineering Process Support

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SOFTWARE PRODUCTIVITY CONSORTIUM

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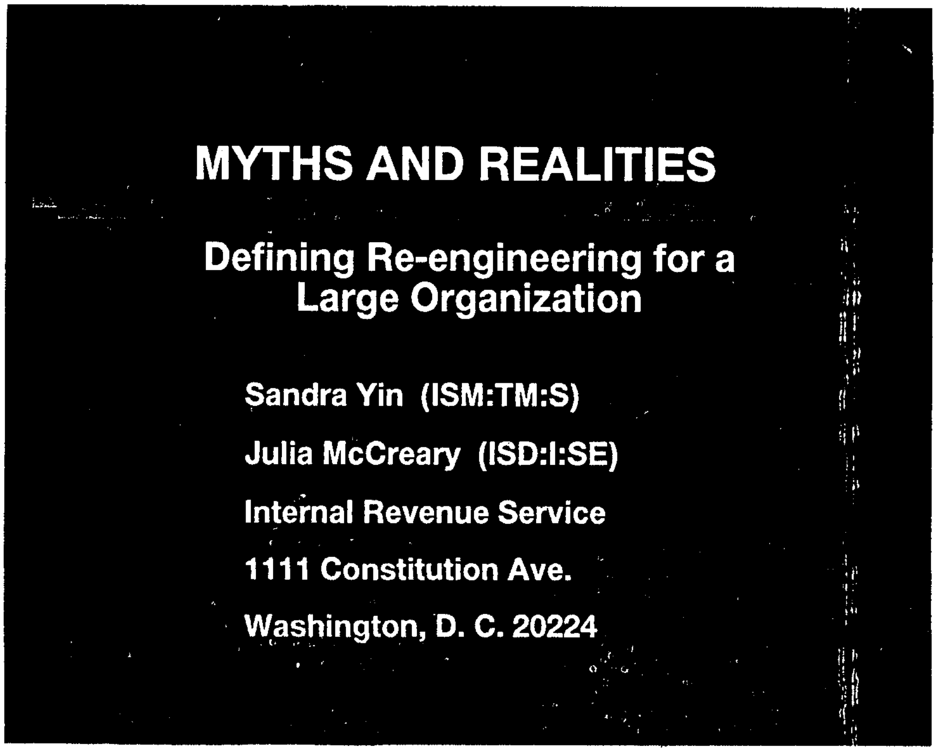


MYTHS AND REALITIES

Defining Re-engineering for a Large Organization

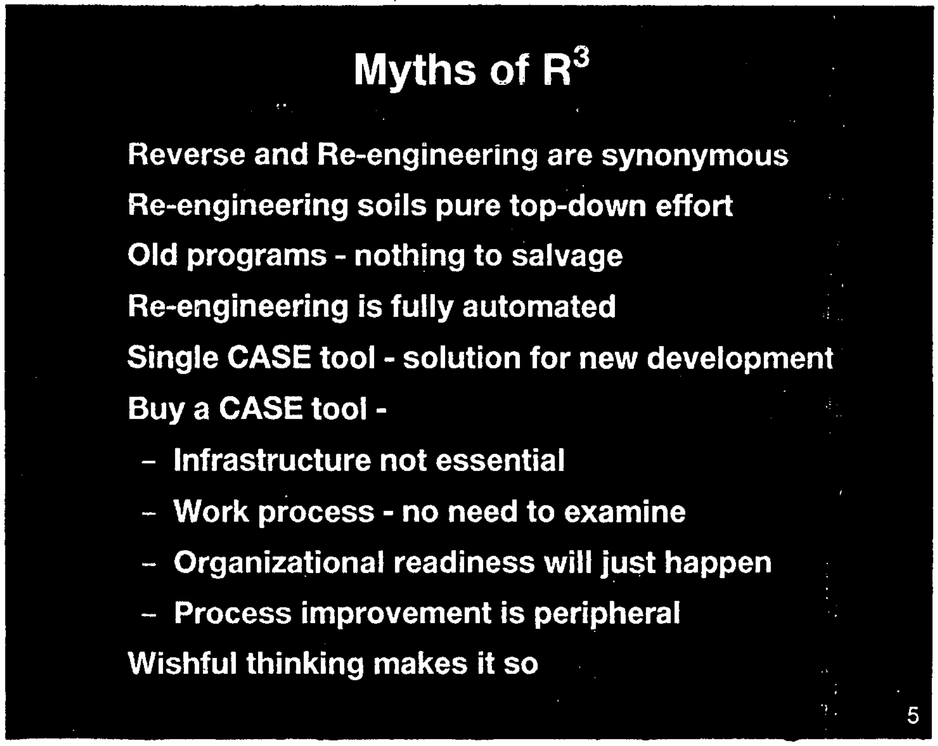
Sandra Yin (ISM:TM:S)

Julia McCreary (ISD:I:SE)

Internal Revenue Service

1111 Constitution Ave.

Washington, D. C. 20224



Myths of R^3

Reverse and Re-engineering are synonymous

Re-engineering soils pure top-down effort

Old programs - nothing to salvage

Re-engineering is fully automated

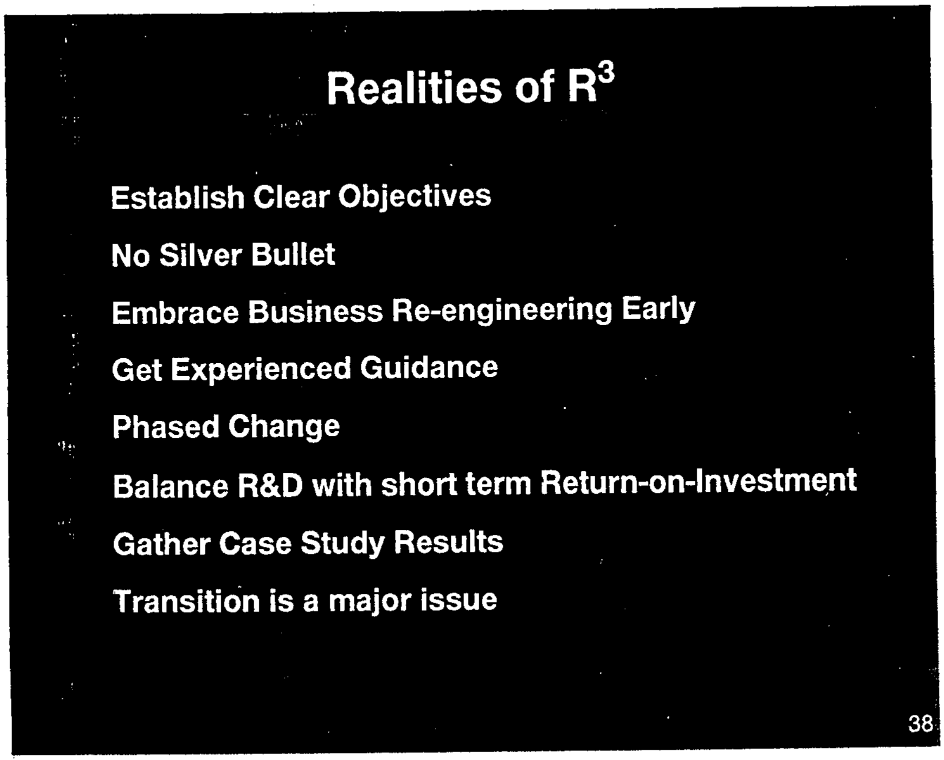
Single CASE tool - solution for new development

Buy a CASE tool -

- Infrastructure not essential
- Work process - no need to examine
- Organizational readiness will just happen
- Process improvement is peripheral

Wishful thinking makes it so

5



Realities of R^3

Establish Clear Objectives

No Silver Bullet

Embrace Business Re-engineering Early

Get Experienced Guidance

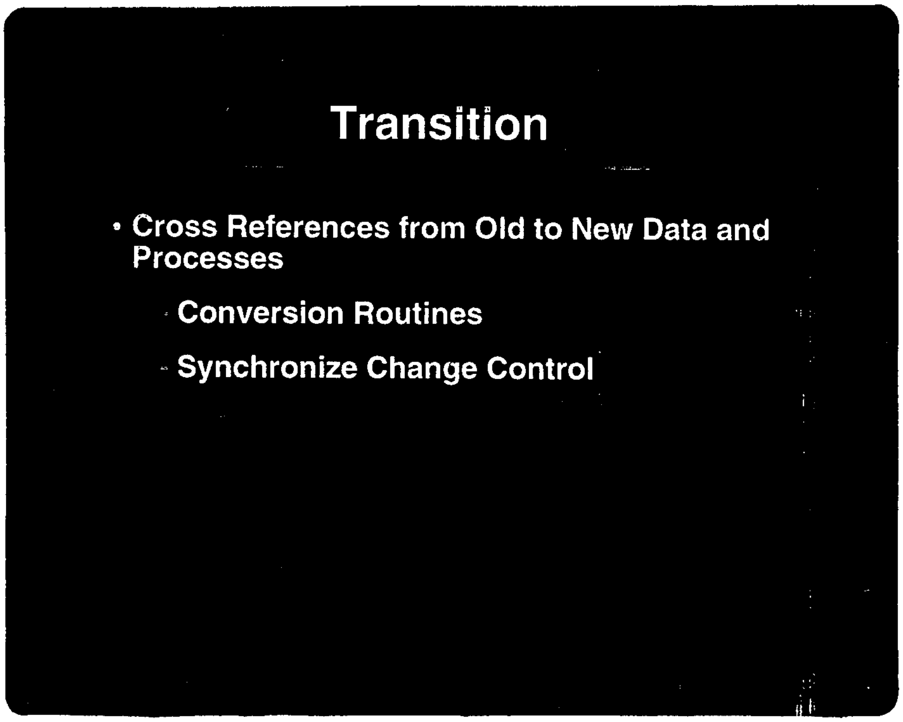
Phased Change

Balance R&D with short term Return-on-Investment

Gather Case Study Results

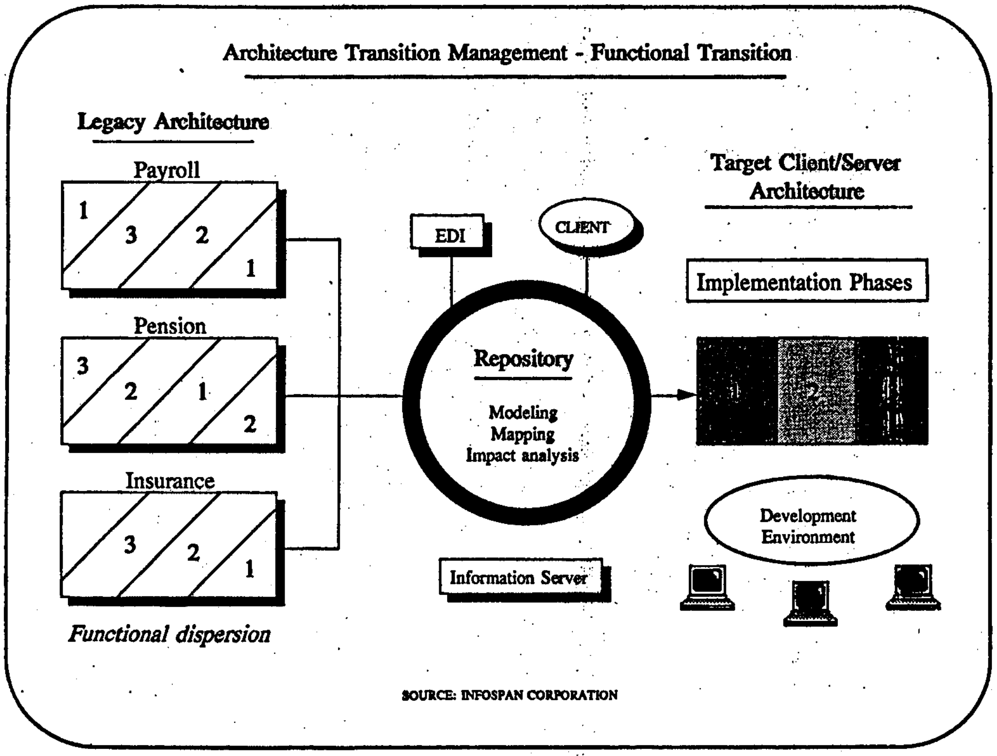
Transition is a major issue

38



Transition

- Cross References from Old to New Data and Processes
  - Conversion Routines
  - Synchronize Change Control



Architecture Transition Management - Functional Transition

Legacy Architecture

Payroll

Pension

Insurance

Functional dispersion

EDI

CLIENT

Repository

Modeling
Mapping
Impact analysis

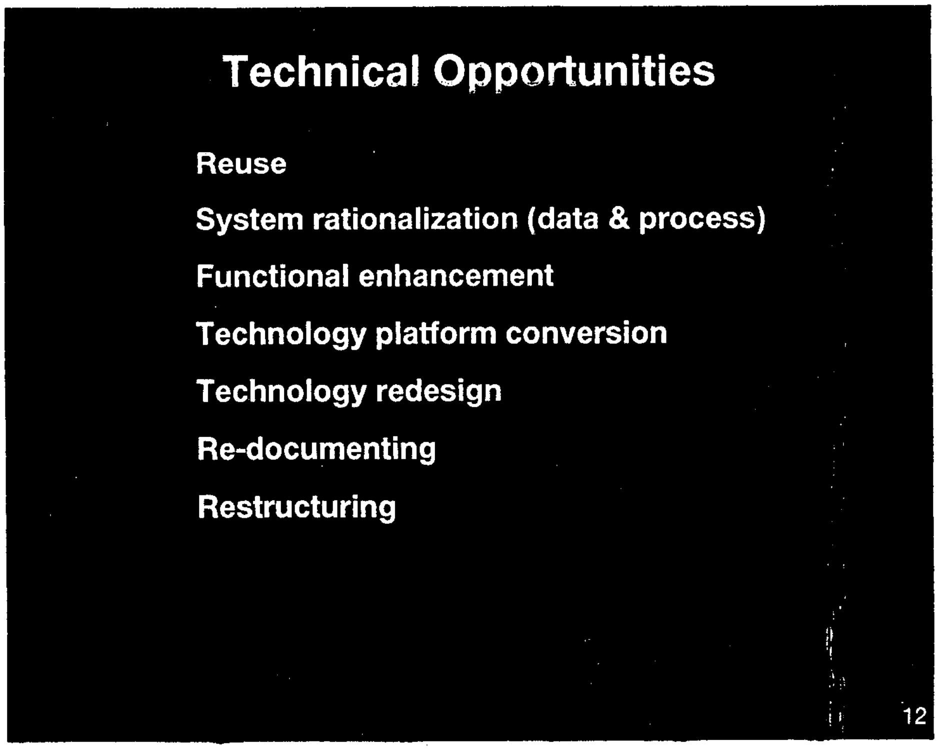
Information Server

Target Client/Server Architecture

Implementation Phases

Development Environment

SOURCE: INFOSPAN CORPORATION



Technical Opportunities

Reuse

System rationalization (data & process)

Functional enhancement

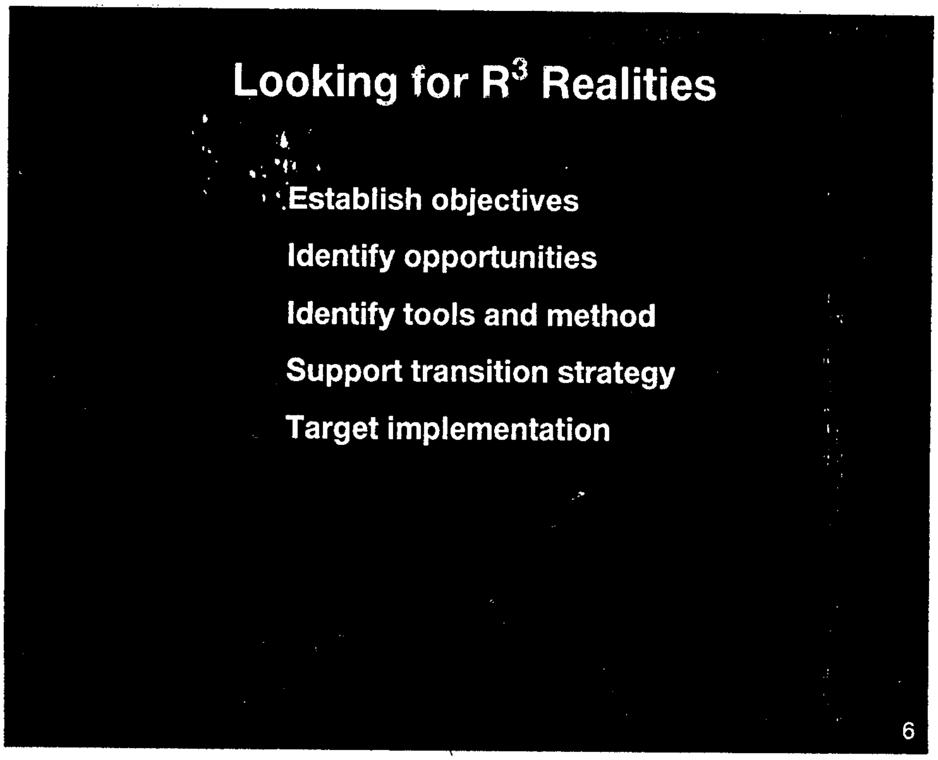
Technology platform conversion

Technology redesign

Re-documenting

Restructuring

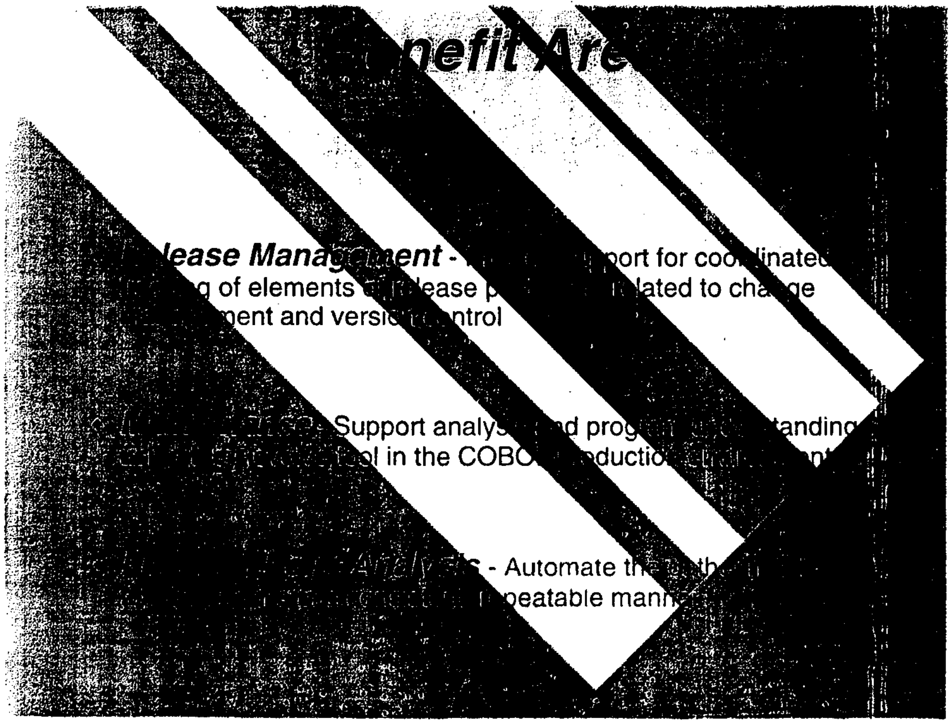
12



Looking for R^3 Realities

- Establish objectives
- Identify opportunities
- Identify tools and method
- Support transition strategy
- Target implementation

6



[illegible]nefit Are[illegible]

[illegible]*lease Management* - [illegible]port for coo[illegible]inate[illegible] [illegible]g of elements [illegible]ease p[illegible]lated to cha[illegible]ge [illegible]ent and versi[illegible]ntrol

[illegible] - Support analy[illegible]d prog[illegible]anding [illegible]l in the COBO[illegible]ductio[illegible]nt[illegible]

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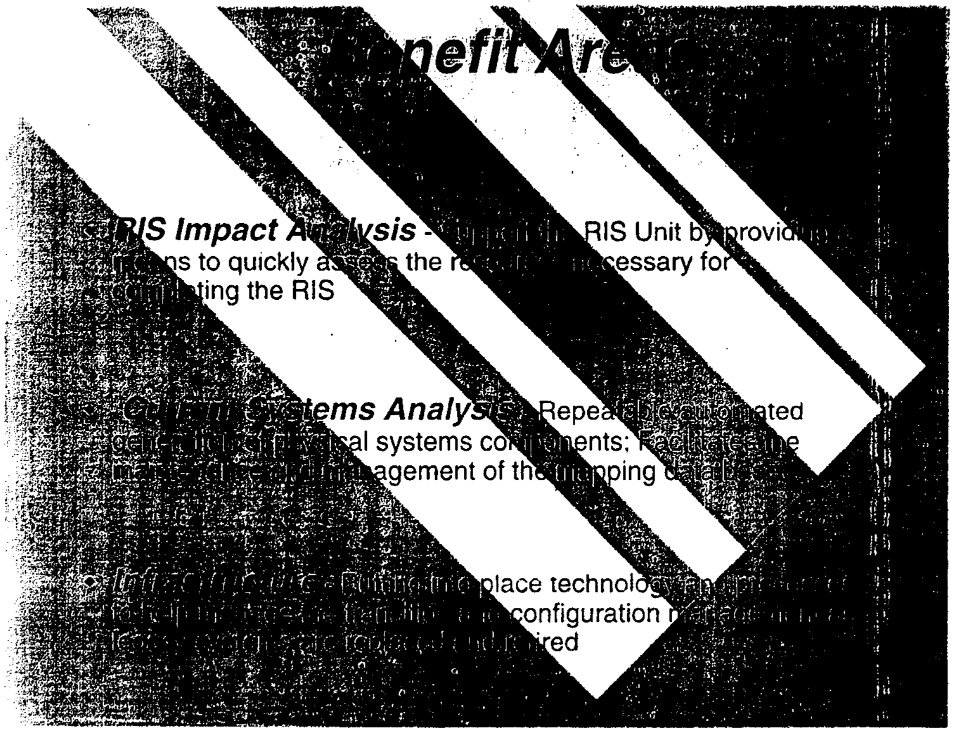

Benefit Areas

- *RIS Impact Analysis* - Support the RIS Unit by providing a means to quickly assess the resources necessary for completing the RIS
- *Current Systems Analysis* - Repeatable automated generation of physical systems components; Facilitates the maintenance and management of the mapping database
- *Infrastructure* - Putting into place technology and processes to help manage the transition and configuration management as legacy systems are replaced and retired

Recommended Future Strategies

- Potential Benefits of R^3
- Develop Plan for IRS
- Define Criteria for IRS
- Evaluate the R^3 Market
- Prototype Projects in ISM
- Technology Transfer

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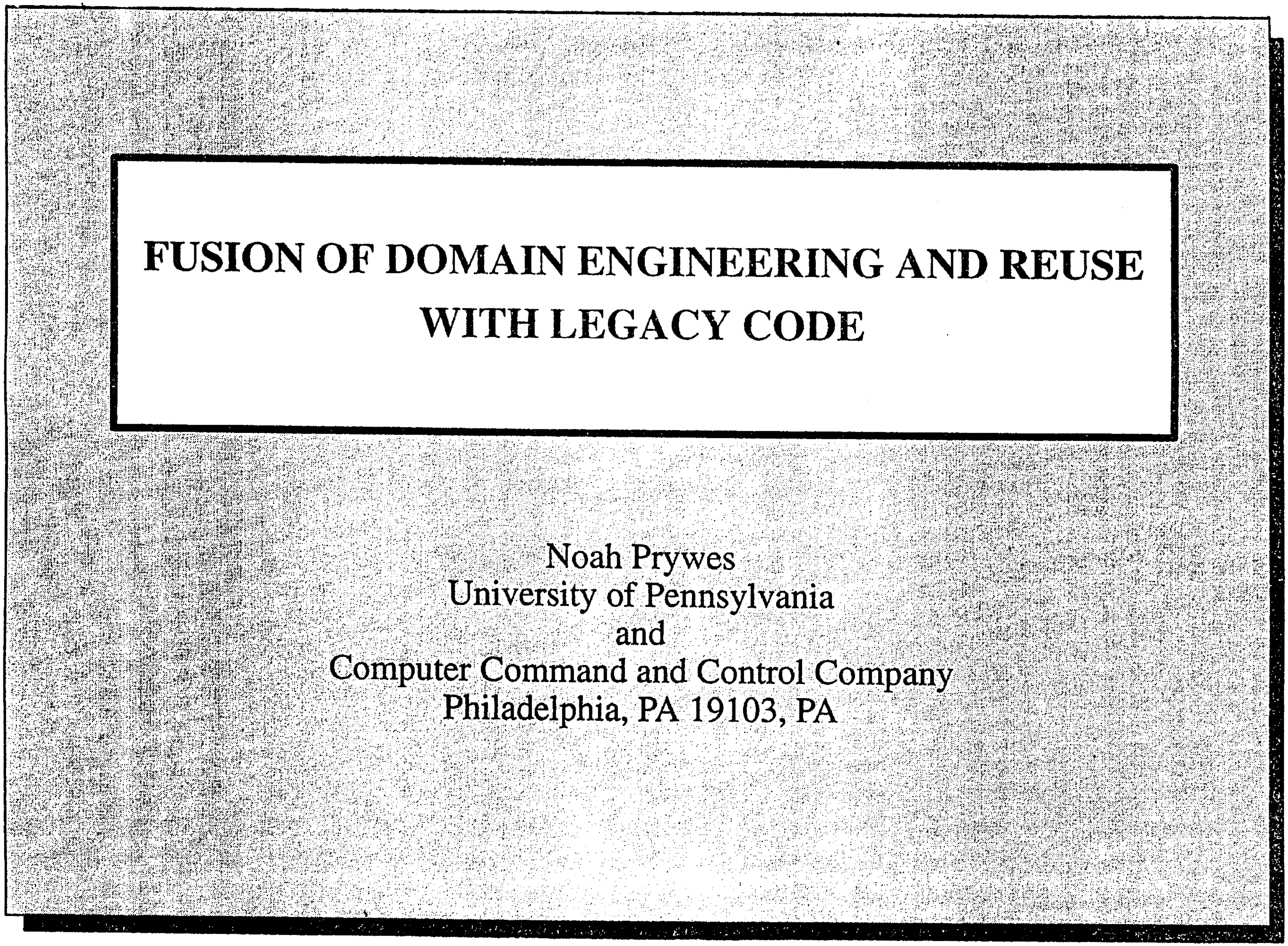
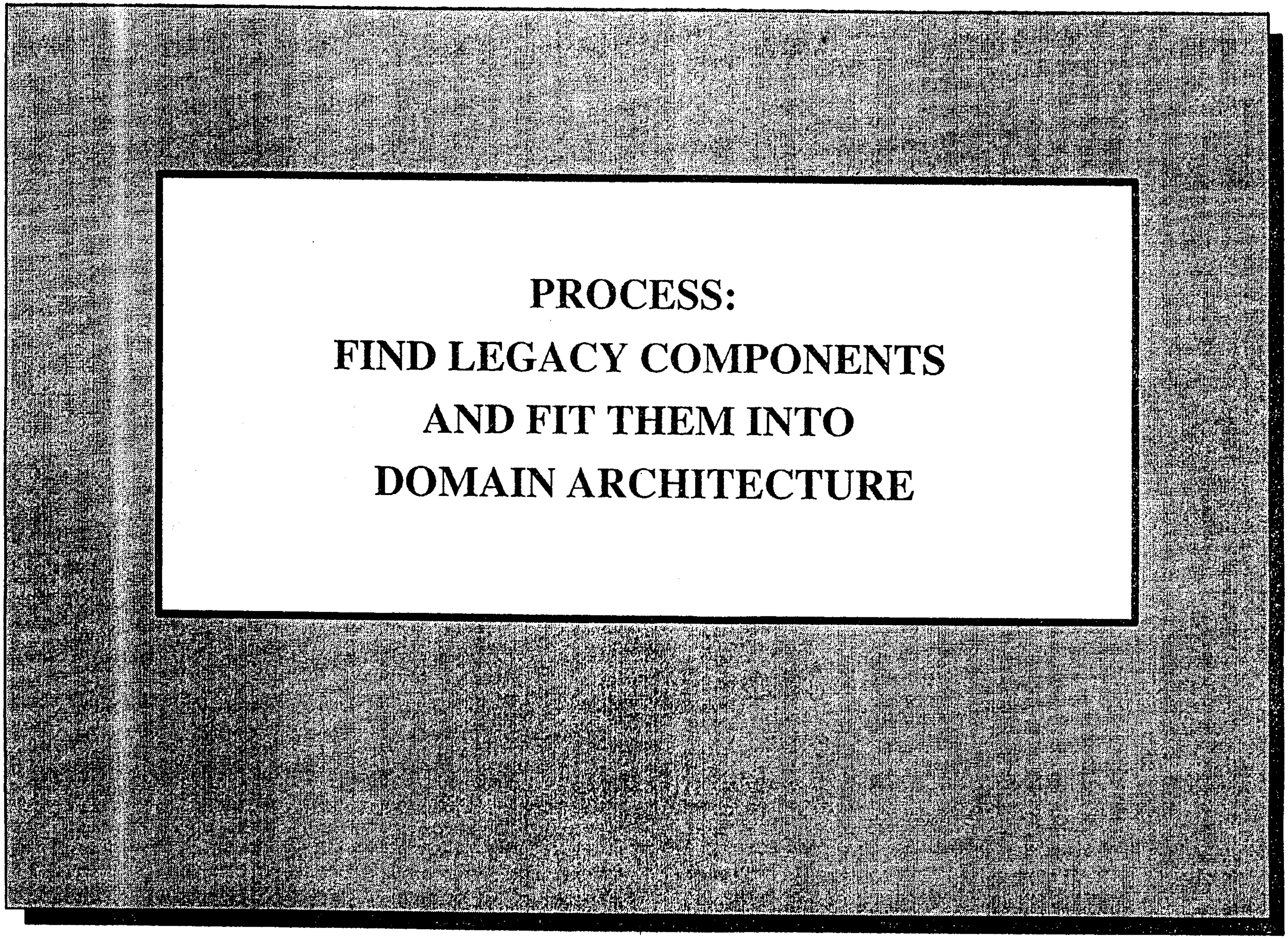


FUSION OF DOMAIN ENGINEERING AND REUSE WITH LEGACY CODE

Noah Prywes
University of Pennsylvania
and
Computer Command and Control Company
Philadelphia, PA 19103, PA

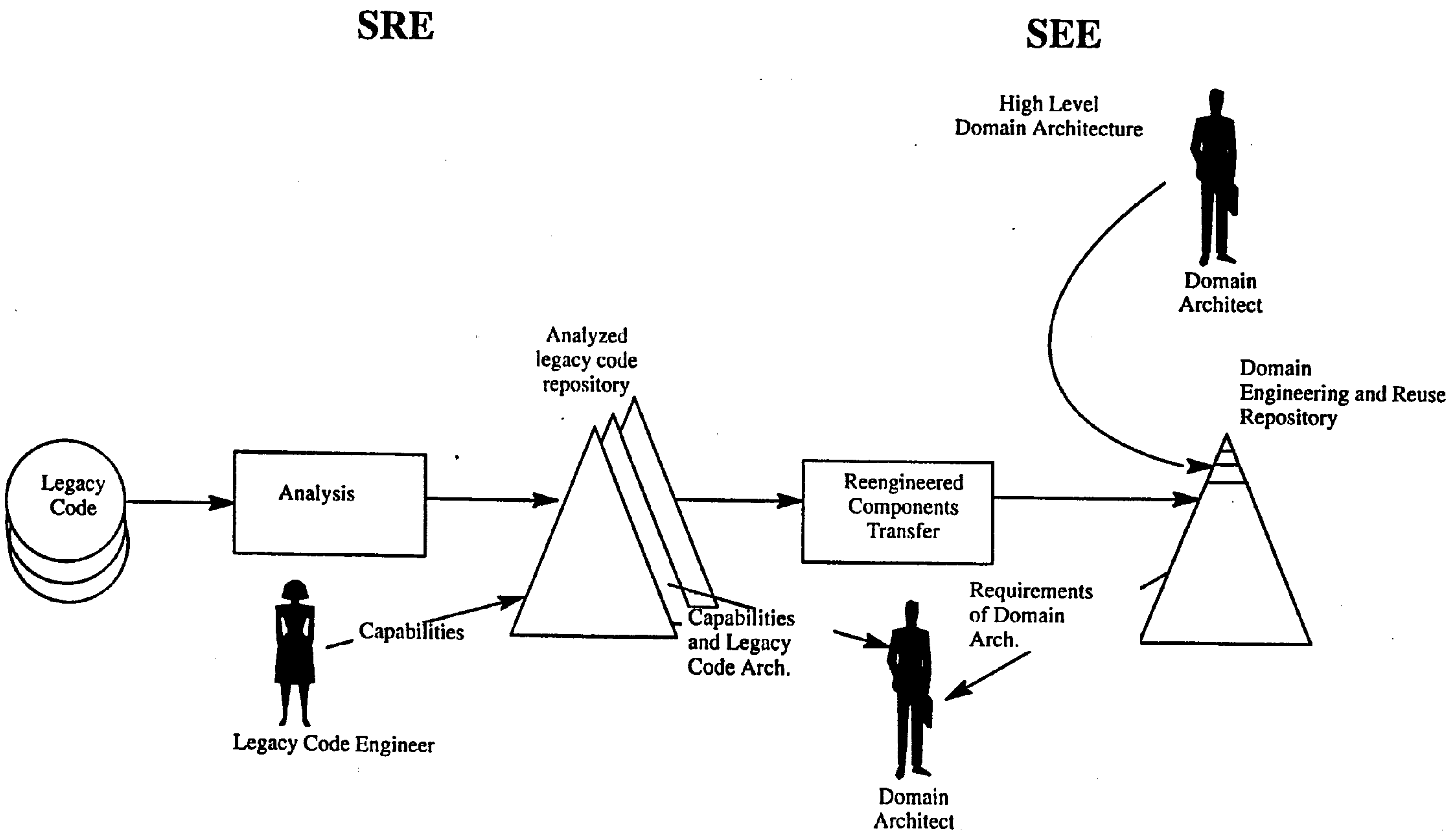
Outline

- PROCESS:
  Find legacy software components and fit them into a domain architecture
- ENABLING TOOLS FOR:
  Find and fit legacy components
  — CCCC's Software Reengineering Environment (SRE)
  Domain Architecture
  — Boeing's Software Engineering Environment (SEE)
- EXPERIENCE: NAWC–TSD
  Domain: Air Vehicle Training Systems (AVTS)
  Legacy: Propulsion Components of T–34, T–44 Trainers
- FUTURE TOOLS:
  Select legacy components with least interfaces
  Test selected components
  Fit selected component into domain architecture

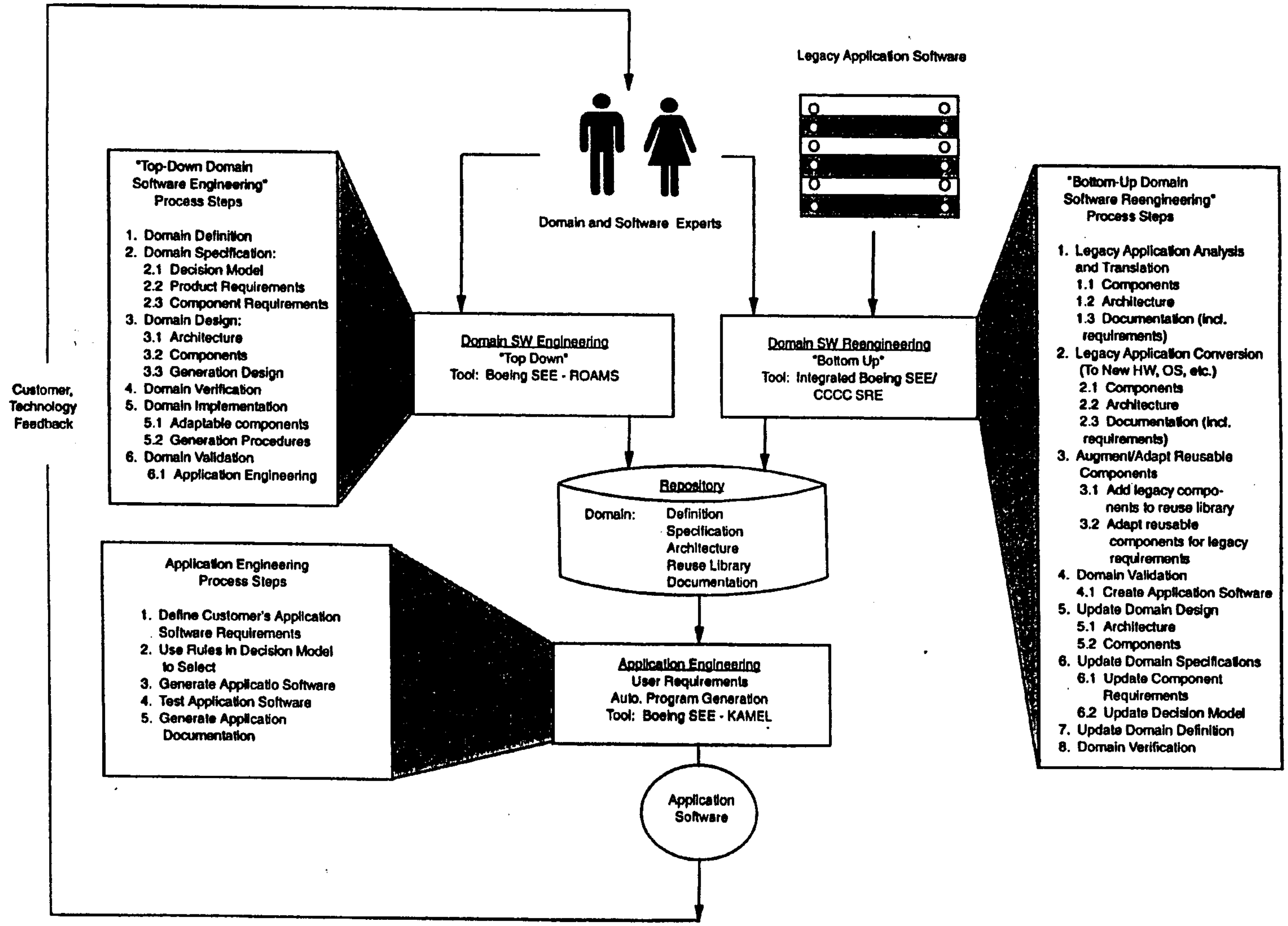


PROCESS:
FIND LEGACY COMPONENTS
AND FIT THEM INTO
DOMAIN ARCHITECTURE

Process Information Flow



Augmented Methodology Process and Steps



"Top-Down Domain Software Engineering" Process Steps

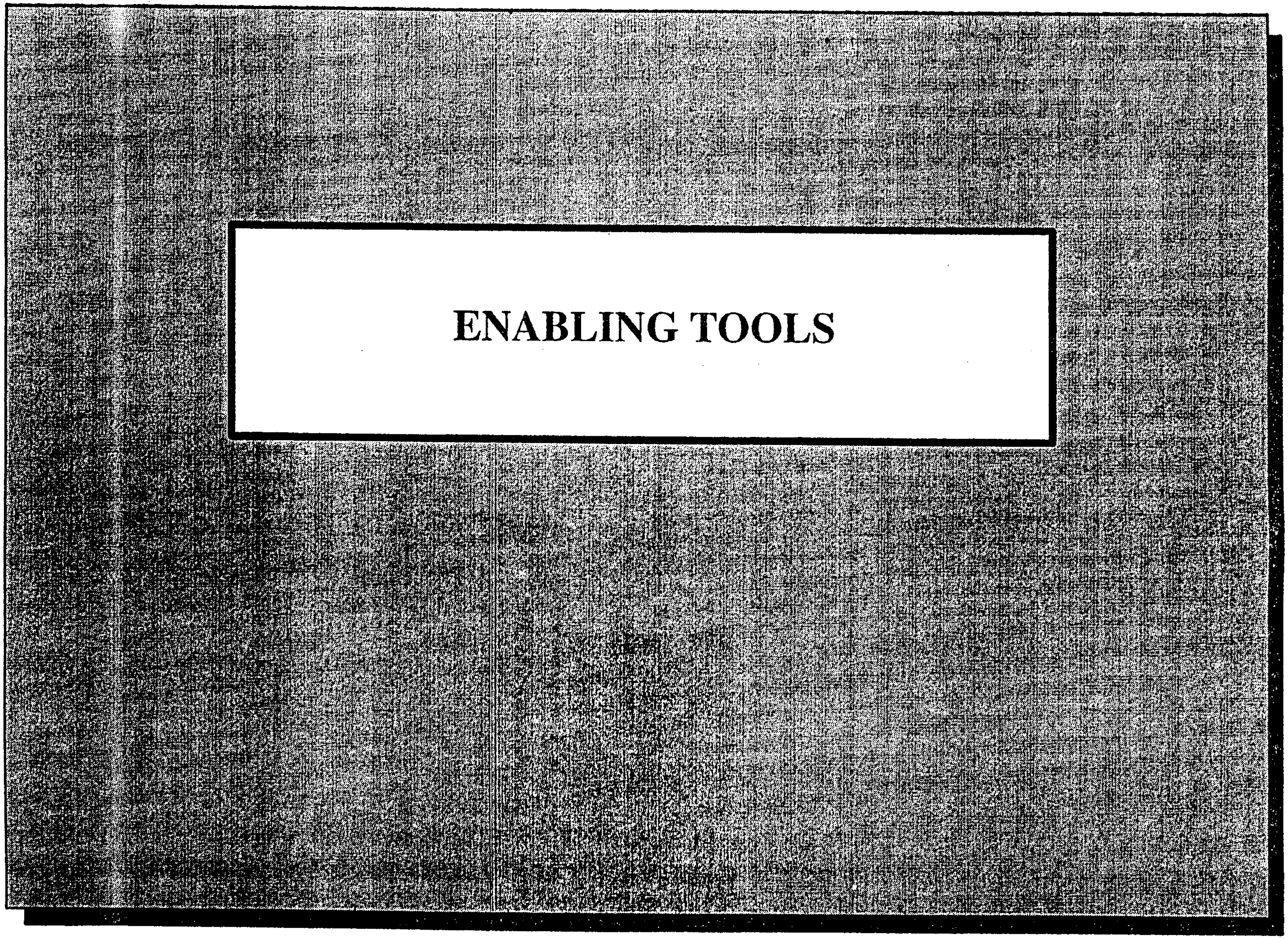
1. Domain Definition
2. Domain Specification:
   2.1 Decision Model
   2.2 Product Requirements
   2.3 Component Requirements
3. Domain Design:
   3.1 Architecture
   3.2 Components
   3.3 Generation Design
4. Domain Verification
5. Domain Implementation
   5.1 Adaptable components
   5.2 Generation Procedures
6. Domain Validation
   6.1 Application Engineering

"Bottom-Up Domain Software Reengineering" Process Steps

1. Legacy Application Analysis and Translation
   1.1 Components
   1.2 Architecture
   1.3 Documentation (incl. requirements)
2. Legacy Application Conversion (To New HW, OS, etc.)
   2.1 Components
   2.2 Architecture
   2.3 Documentation (incl. requirements)
3. Augment/Adapt Reusable Components
   3.1 Add legacy components to reuse library
   3.2 Adapt reusable components for legacy requirements
4. Domain Validation
   4.1 Create Application Software
5. Update Domain Design
   5.1 Architecture
   5.2 Components
6. Update Domain Specifications
   6.1 Update Component Requirements
   6.2 Update Decision Model
7. Update Domain Definition
8. Domain Verification

Application Engineering Process Steps

1. Define Customer's Application Software Requirements
2. Use Rules in Decision Model to Select
3. Generate Applicatio Software
4. Test Application Software
5. Generate Application Documentation



ENABLING TOOLS

Nodes and Edges in SRE Analyzed Legacy Code Repository

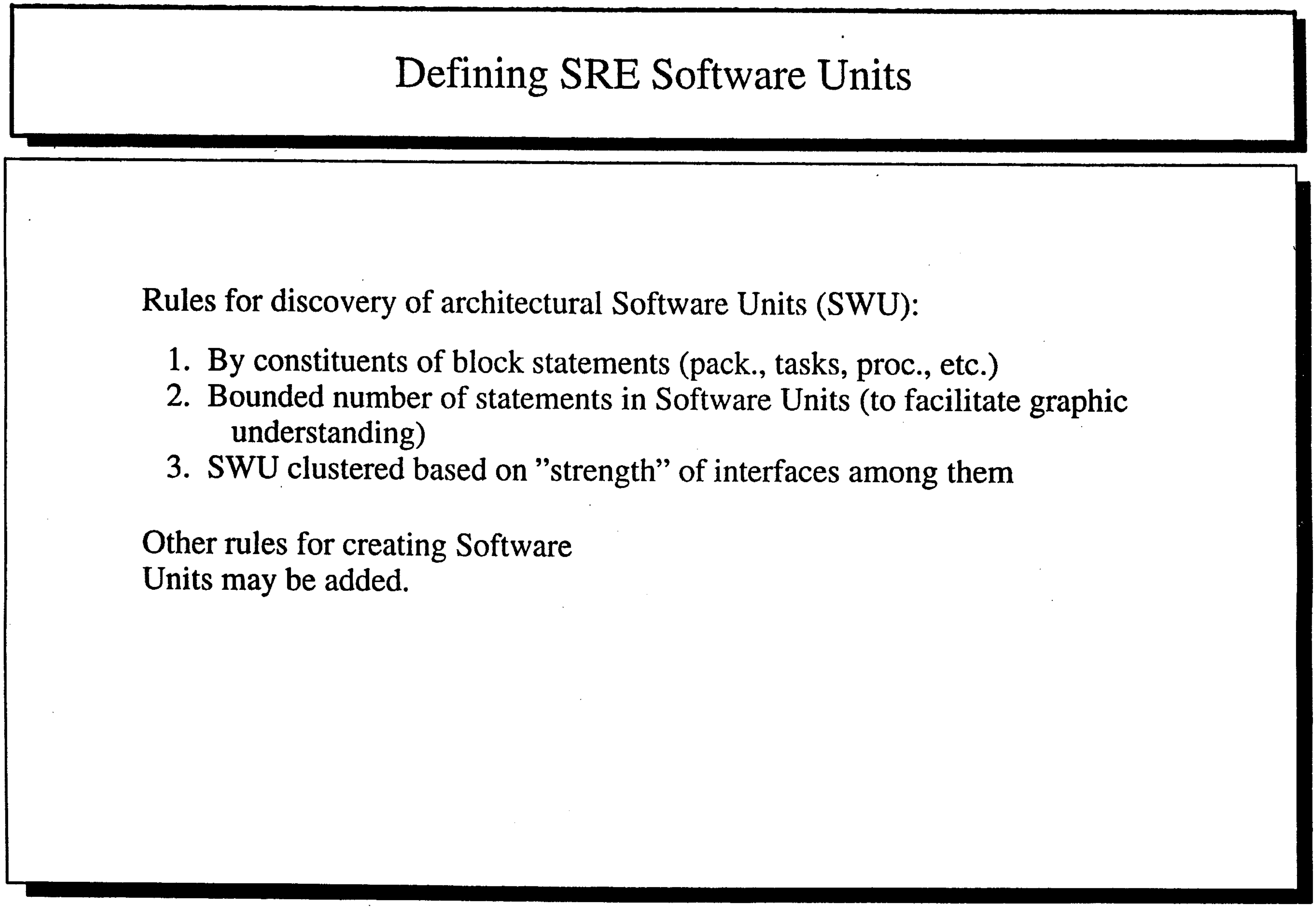
Nodes: software entities

1. At the lowest level: statements
2. Hierarchical Software Units (SWU) contain statements, data, and COTS with documentation.

Edges (Relationships between nodes):

1. Scope: between parent SWU and its children SWUs, in order of precedence; between block statements and their constituents
2. Memory: between a variable reference and its declaration
3. Type: between type of variable and its declaration
4. Call: between procedure/function declaration and its caller
5. Message: between message call and its destination task entry point
6. Context: between with/use and respective package, etc.

Other types of edges may be added.



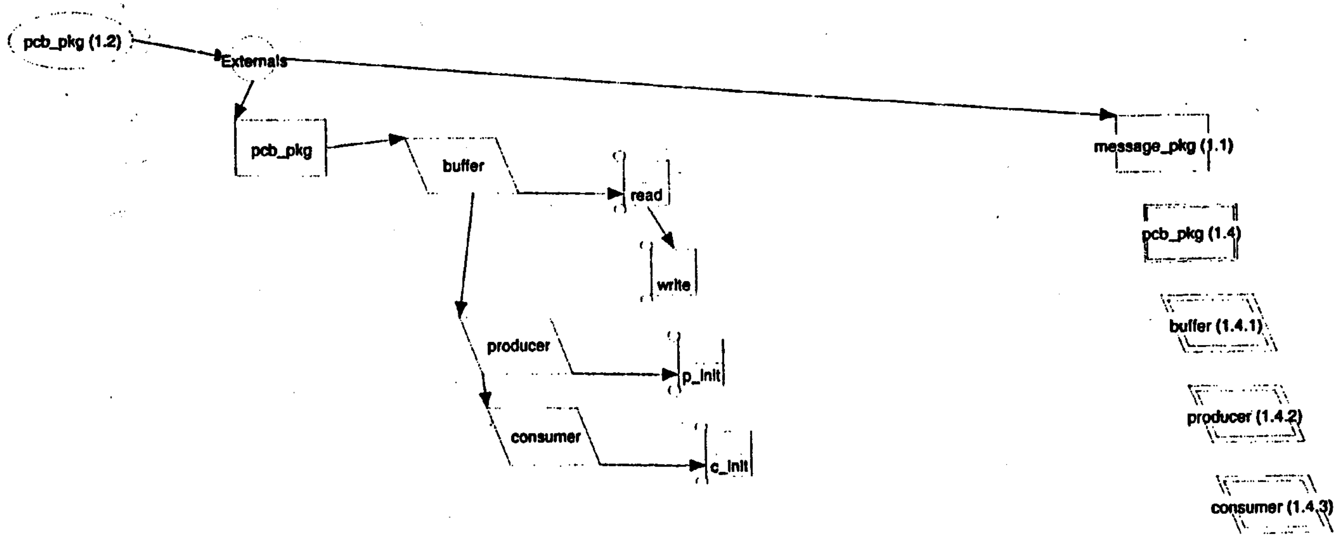
Defining SRE Software Units

Rules for discovery of architectural Software Units (SWU):

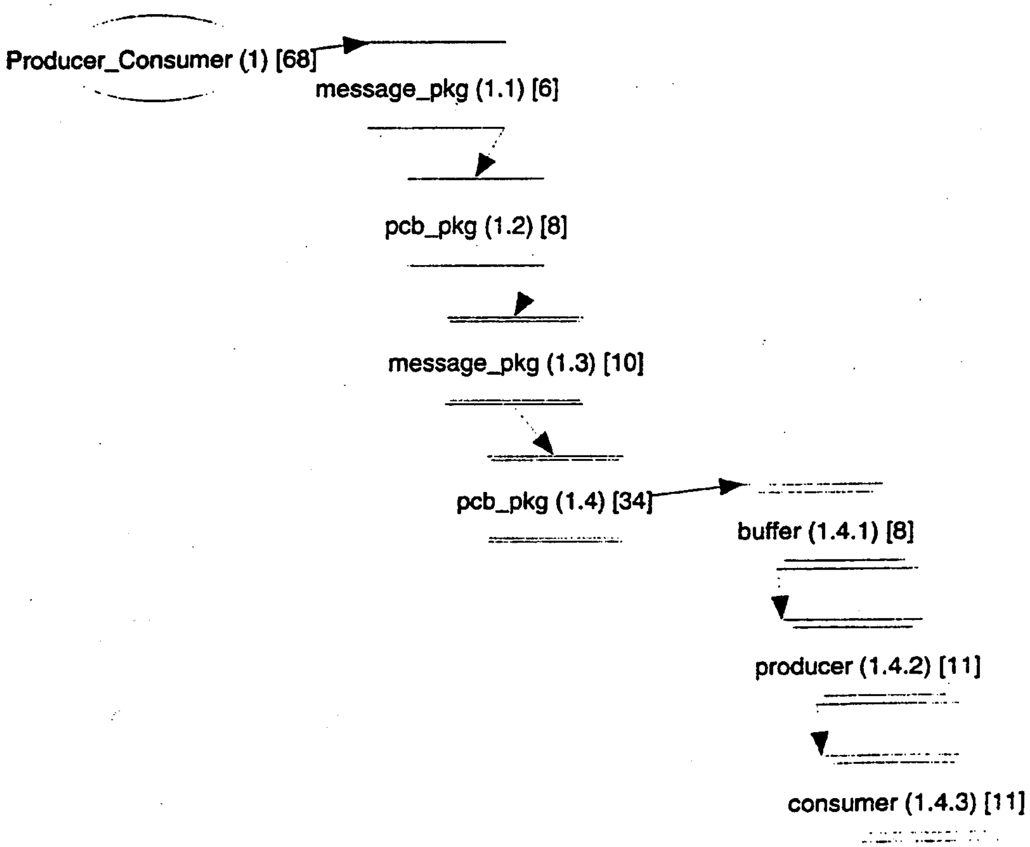
1. By constituents of block statements (pack., tasks, proc., etc.)
2. Bounded number of statements in Software Units (to facilitate graphic understanding)
3. SWU clustered based on "strength" of interfaces among them

Other rules for creating Software
Units may be added.

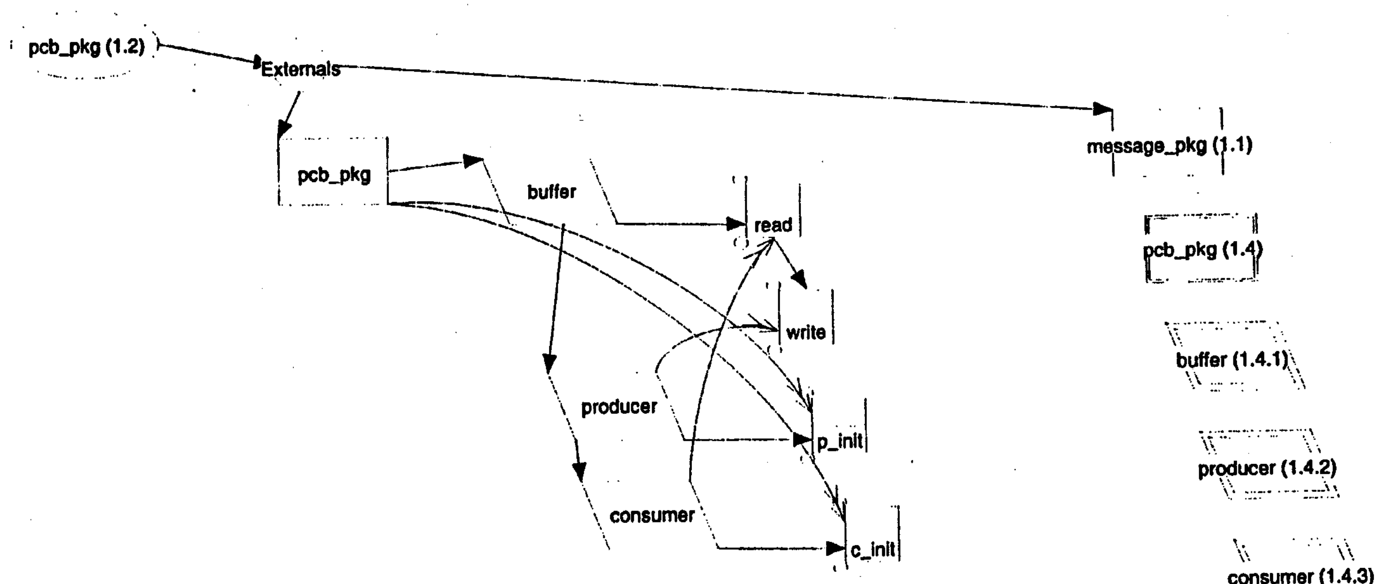
PCB_Pkg Scope Graph



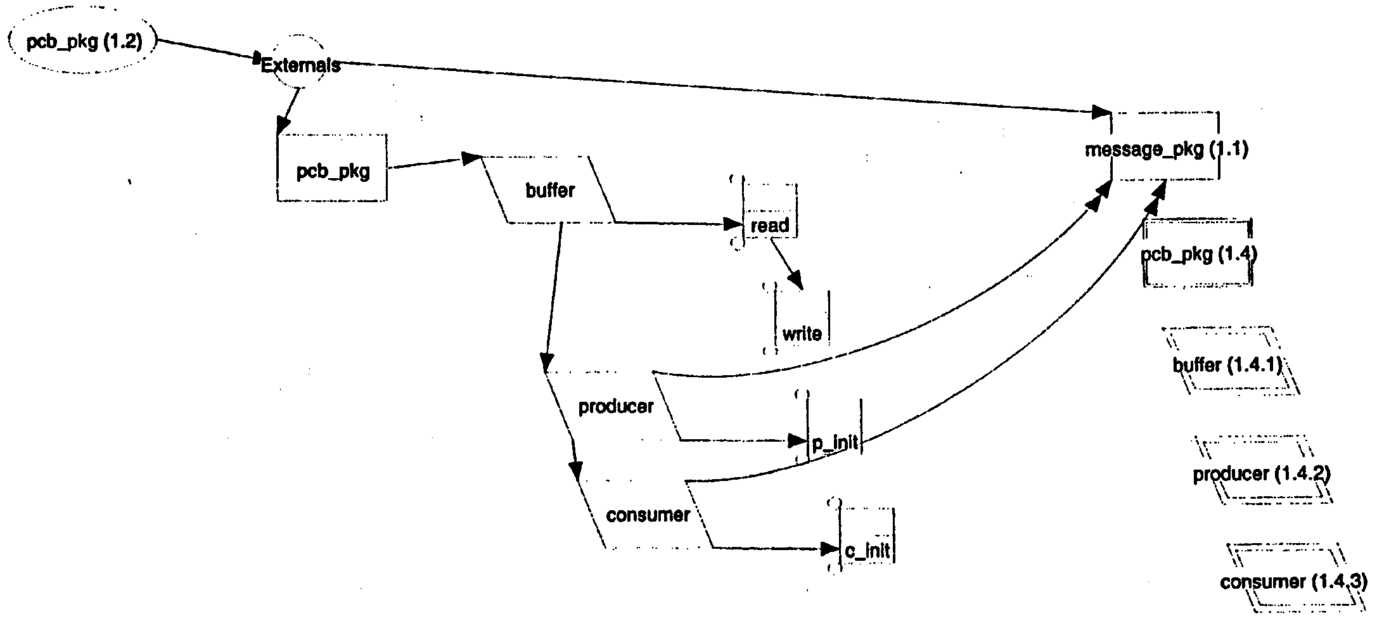
Producer_Consumer Unit Map



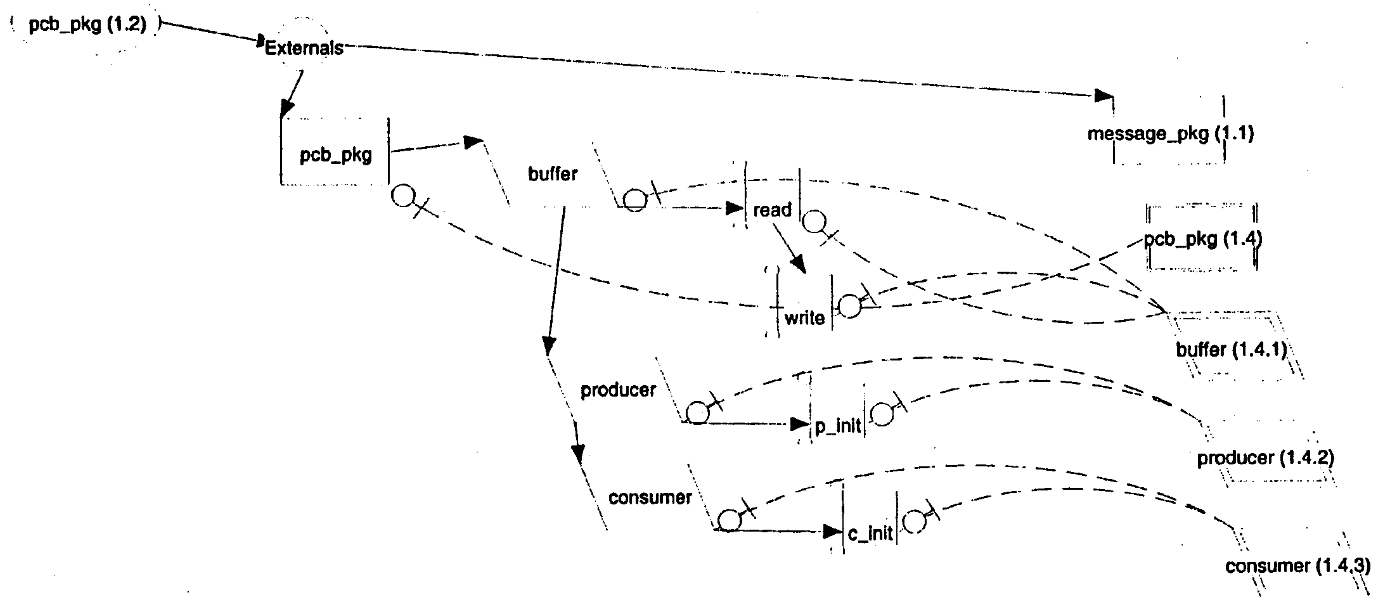
PCB_Pkg Message Relations



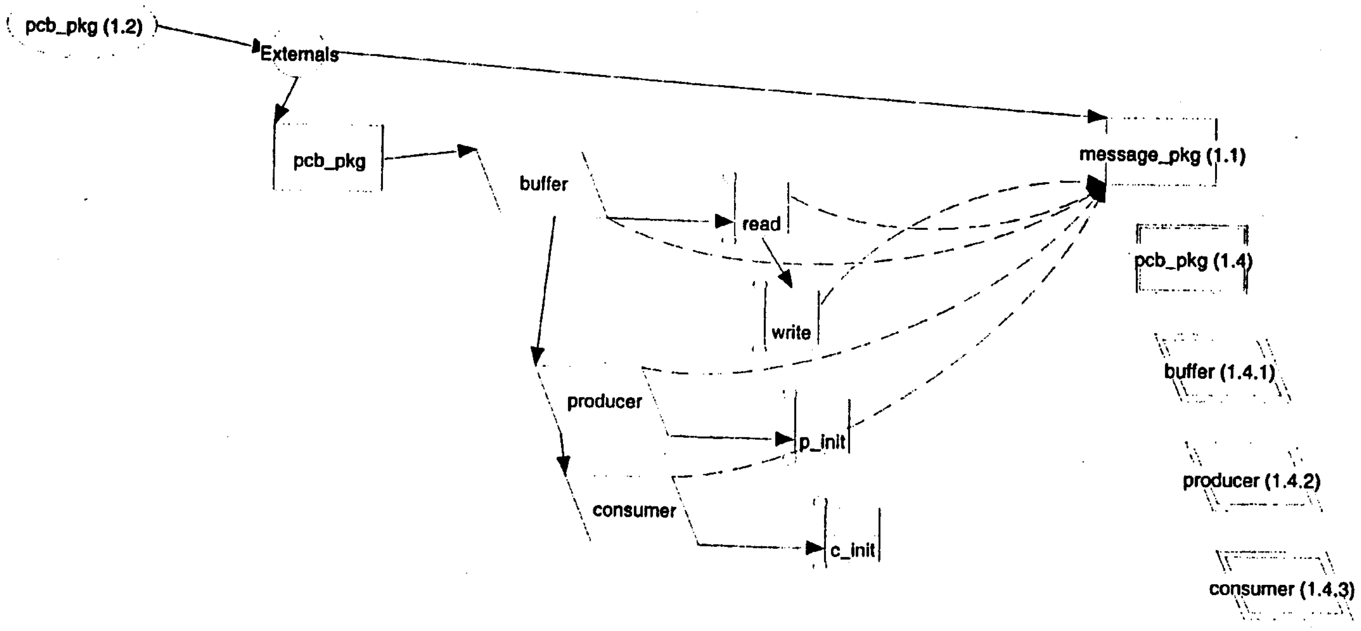
PCB_Pkg Call Relations



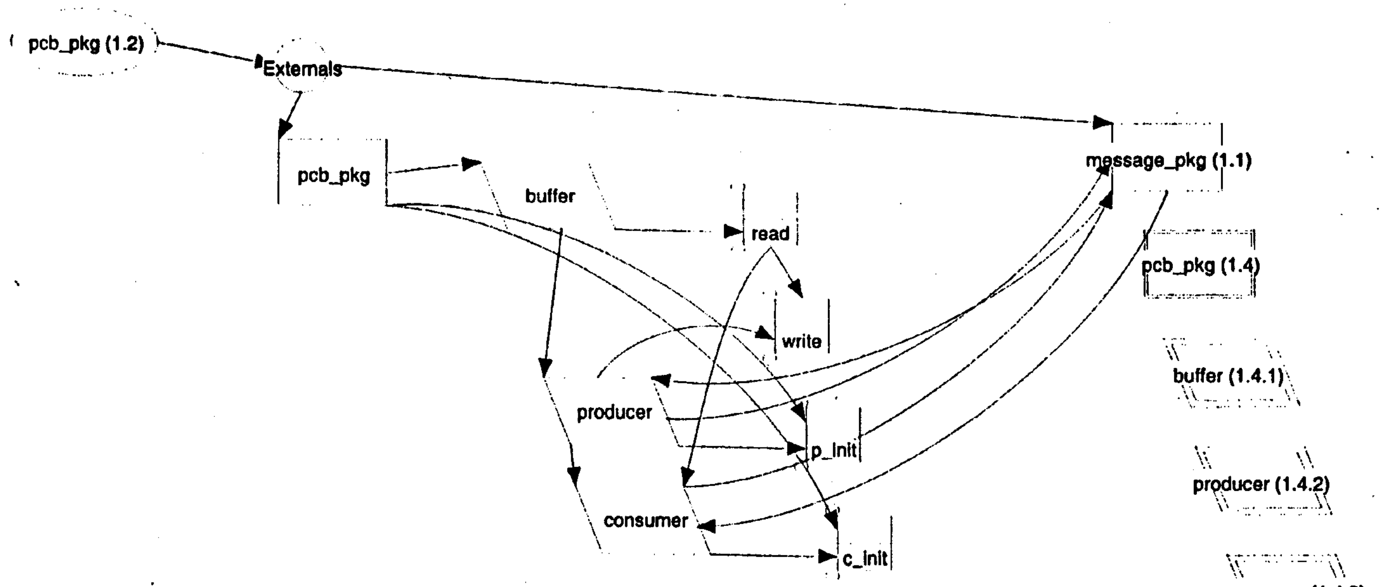
PCB_Pkg Context Relations



PCB_Pkg Type Relations

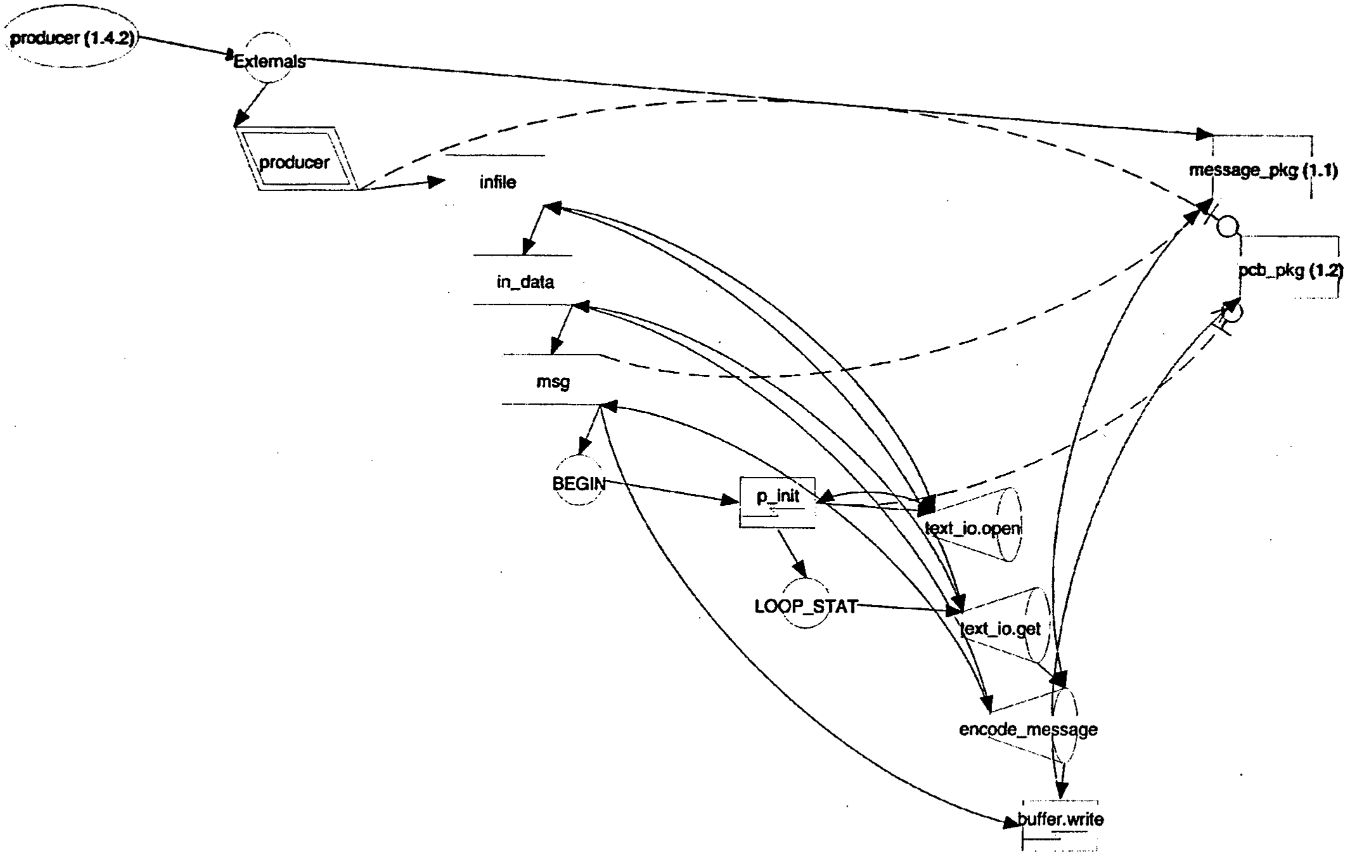


PCB_Pkg Memory Relations

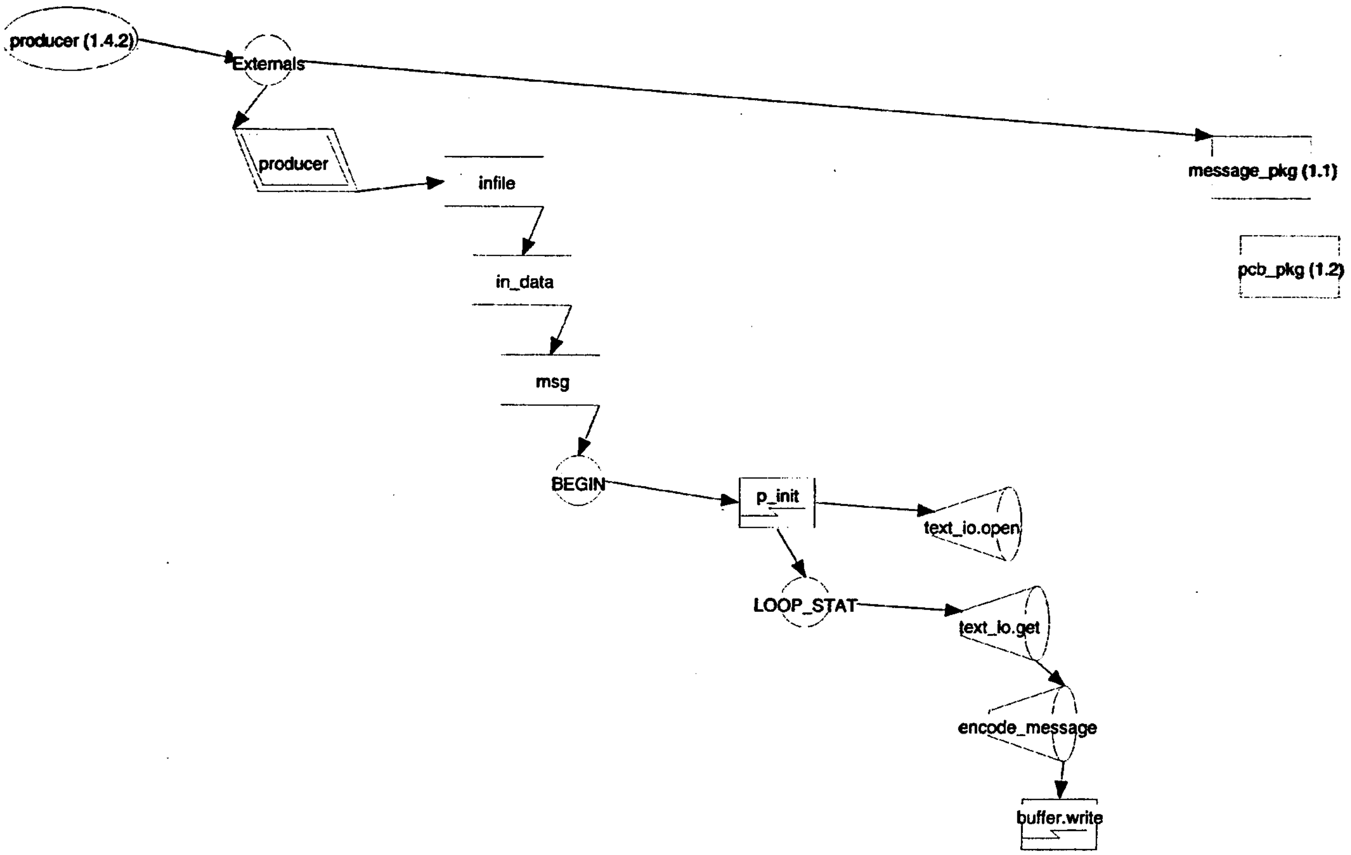


PCB_Pkg Interface Report

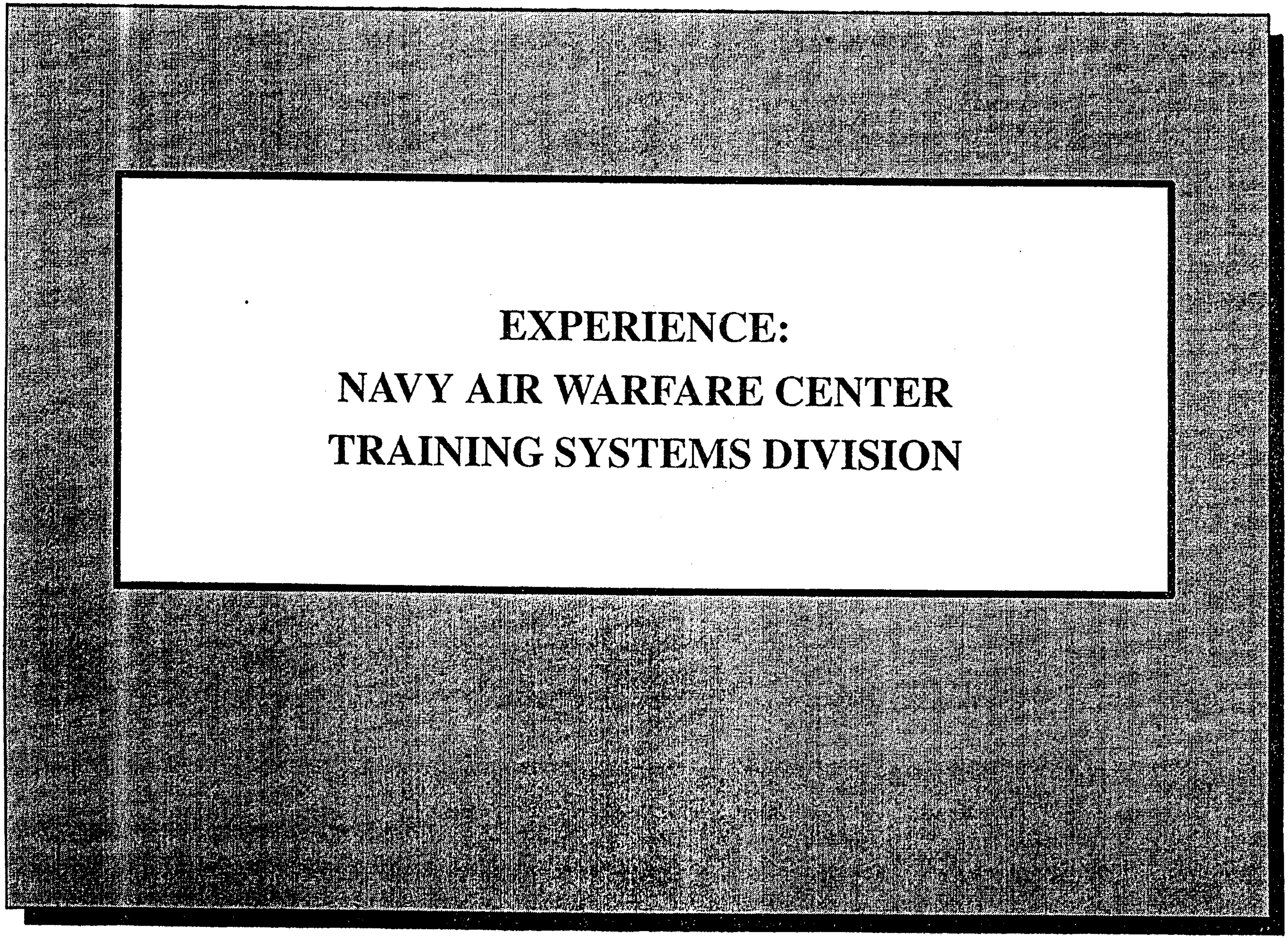
```
/*-------------------------------------------------------------------*/
/*                  INTERFACE REPORT for pcb_pkg (1.2)
/*-------------------------------------------------------------------*/
                       EXTERNAL                   INTERNAL
                  -------------------        -------------------
CALL:
  1: [PROCEDURE encode_message ( data : IN integer ; msg : OUT message ) ; ] (1.1)
          <--- [encode_message ( in_data , msg ) ; ]
  2: [FUNCTION decode_message ( msg : IN message )  RETURN integer ; ] (1.1)
          <--- [out_data := decode_message(msg) ; ]


MEMORY:
  3: [PROCEDURE encode_message ( data : IN integer ; msg : OUT message ) ; ] (1.1)
          ---> [encode_message ( in_data , msg ) ; ]
  4: [PROCEDURE encode_message ( data : IN integer ; msg : OUT message ) ; ] (1.1)
          <--- [encode_message ( in_data , msg ) ; ]
  5: [FUNCTION decode_message ( msg : IN message )  RETURN integer ; ] (1.1)
          <--- [out_data := decode_message(msg) ; ]
  6: [FUNCTION decode_message ( msg : IN message )  RETURN integer ; ] (1.1)
          ---> [out_data := decode_message(msg) ; ]


TYPE:
  7: [TYPE message IS ] (1.1)
          <--- [msg : message ; ]
  8: [TYPE message IS ] (1.1)
          <--- [msg : message ; ]
  9: [TYPE message IS ] (1.1)
          <--- [ACCEPT read ( data : OUT message ) DO     ]
 10: [TYPE message IS ] (1.1)  .
          <--- [ACCEPT write ( data : IN message ) DO     ]
 11: [TYPE message IS ] (1.1)
          <--- [contents : message ; ]
 12: [TYPE message IS ] (1.1)
          <--- [ENTRY write ( data : IN message ) ; ]
 13: [TYPE message IS ] (1.1)
          <--- [ENTRY read ( data : OUT message ) ; ]


CONTEXT:
 14: [TASK BODY buffer IS ] (1.4.1)
          <--- [TASK buffer IS ]
 15: [ACCEPT read ( data : OUT message ) DO      ] (1.4.1)
          <--- [ENTRY read ( data : OUT message ) ; ]
 16: [ACCEPT write ( data : IN message ) DO      ] (1.4.1)
          <--- [ENTRY write ( data : IN message ) ; ]
 17: [TASK BODY producer IS ] (1.4.2)
          <--- [TASK producer IS ]
 18: [ACCEPT p_init ( filename : IN string ) DO      ] (1.4.2)
          <--- [ENTRY p_init ( filename : IN string ) ; ]
 19: [TASK BODY consumer IS ] (1.4.3)
          <--- [TASK consumer IS ]
 20: [ACCEPT c_init ( filename : IN string ) DO      ] (1.4.3)
          <--- [ENTRY c_init ( filename : IN string ) ; ]
 21: [PACKAGE BODY pcb_pkg IS ] (1.4)
          <--- [PACKAGE pcb_pkg IS ]
```



Producer (1.4.2) Relations Graph

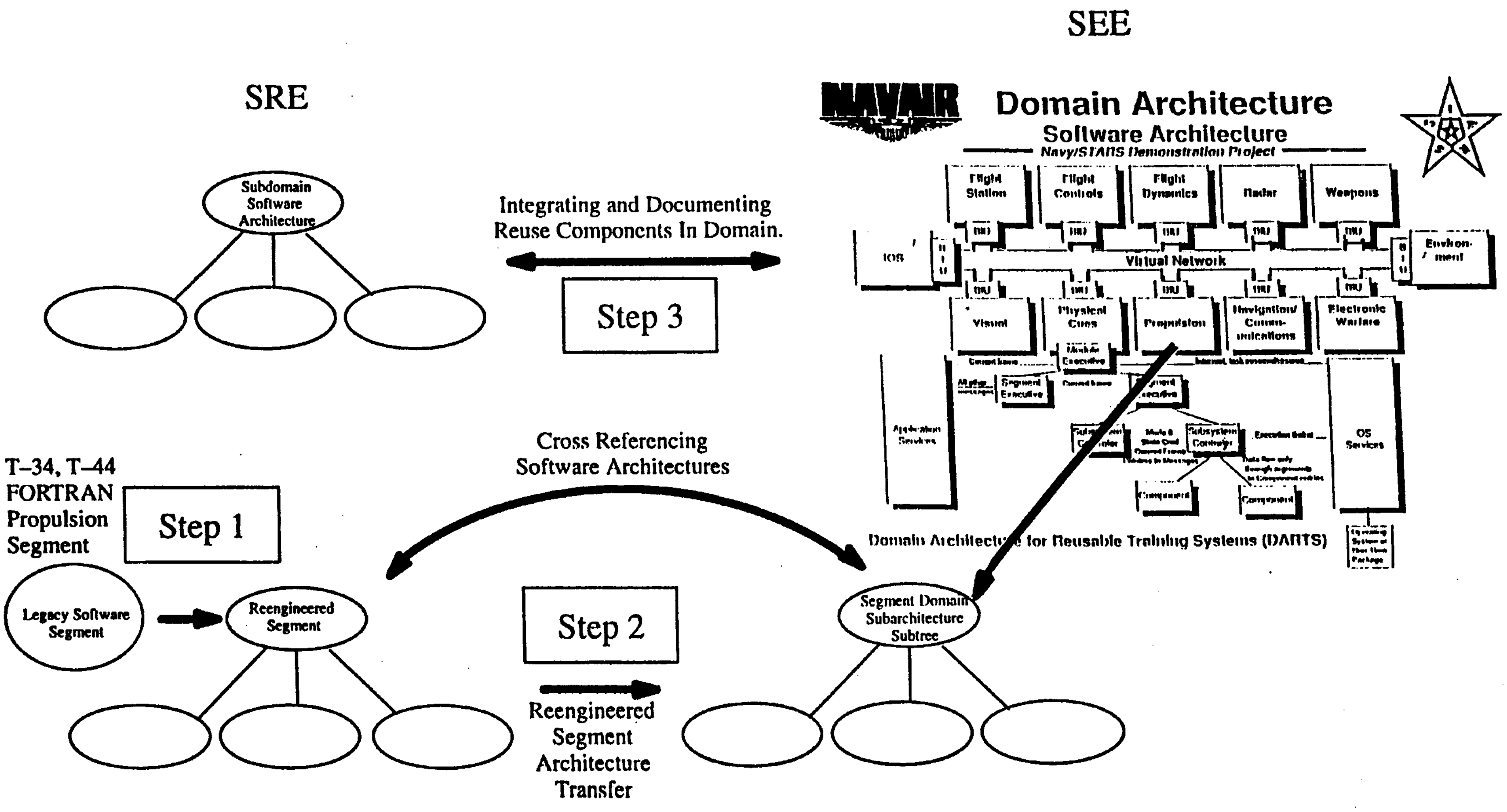


Producer (1.4.2) Scope Graph



EXPERIENCE:
NAVY AIR WARFARE CENTER
TRAINING SYSTEMS DIVISION

Fitting Components Derived from Legacy Propulsion Segment of T–34, T–44 into High Level DARTS Software Architecture



SRE

SEE

T–34, T–44 FORTRAN Propulsion Segment

Step 1

Step 2

Step 3

Integrating and Documenting Reuse Components In Domain.

Cross Referencing Software Architectures

Reengineered Segment Architecture Transfer

Domain Architecture for Reusable Training Systems (DARTS)

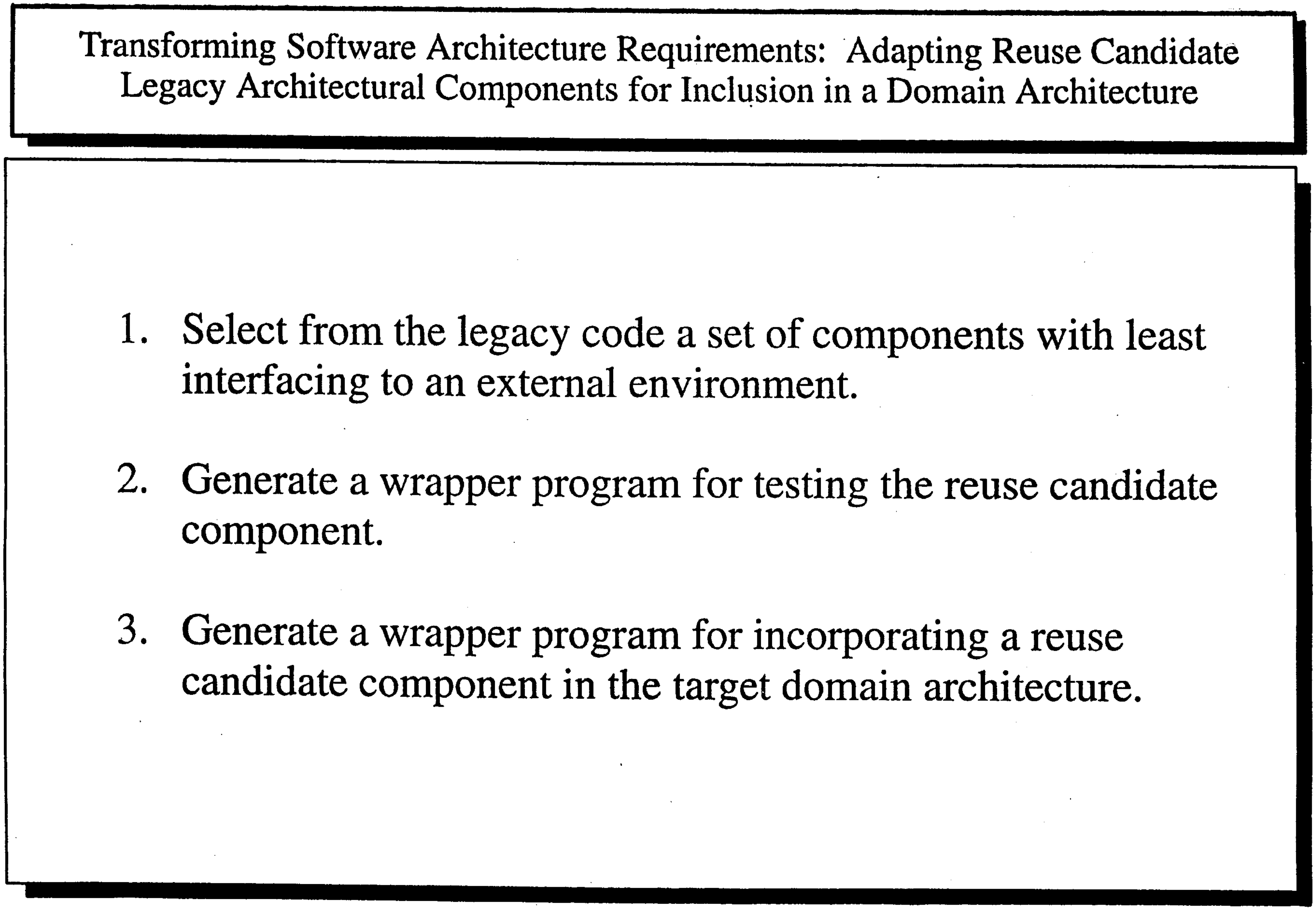
Process Steps for Fusion AVTS Domain with Propulsion Components of Trainers of T–34 and T–44 Legacy Code

Step 1: Legacy code processing: Translated T–34 and T–44 FORTRAN propulsion code to Ada and produced documentation (a map, and for each software unit: code diagrams, data flow diagram, interfaces, comments and Ada code). Then tested the components code to assure that they are operating as expected using the T–34 test platform.

Step 2: Legacy code reengineering: Provided textual description of capabilities of the software units produced in Step 1. Matched these capabilities with the decision model for the propulsion segment of DARTS. The decision model shows common and variable requirements of components.

Step 3: Integration of reengineered legacy code into DARTS domain architecture: Modified interfaces of components to adhere to DARTS communications scheme, thus creating reusable components. An estimate of $15/LOC was made at the end of this step.

Step 4: Application engineering: This step is currently underway. It will create T–34 application software for propulsion segment from the DARTS reuse components developed in Step 3.

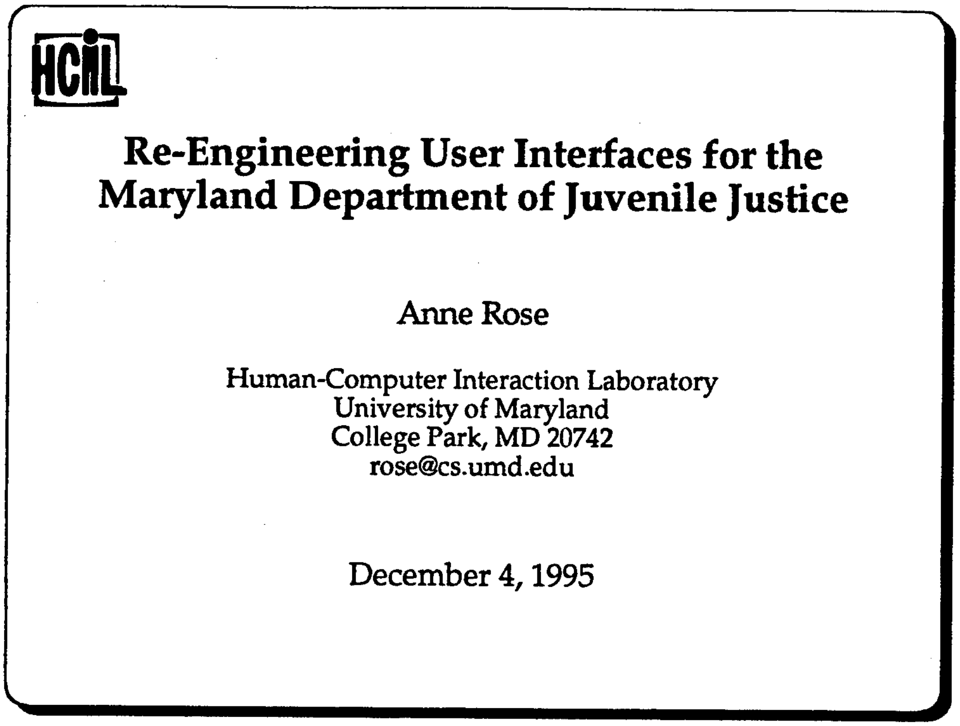


Transforming Software Architecture Requirements: Adapting Reuse Candidate Legacy Architectural Components for Inclusion in a Domain Architecture

1. Select from the legacy code a set of components with least interfacing to an external environment.

2. Generate a wrapper program for testing the reuse candidate component.

3. Generate a wrapper program for incorporating a reuse candidate component in the target domain architecture.

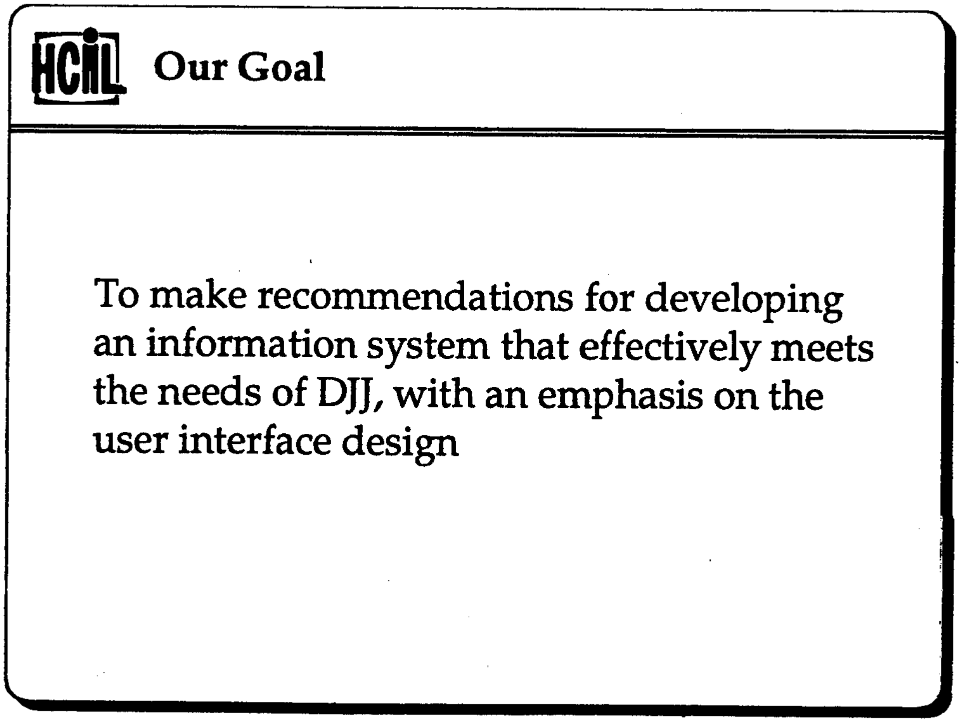


Re-Engineering User Interfaces for the Maryland Department of Juvenile Justice

Anne Rose

Human-Computer Interaction Laboratory
University of Maryland
College Park, MD 20742
rose@cs.umd.edu

December 4, 1995



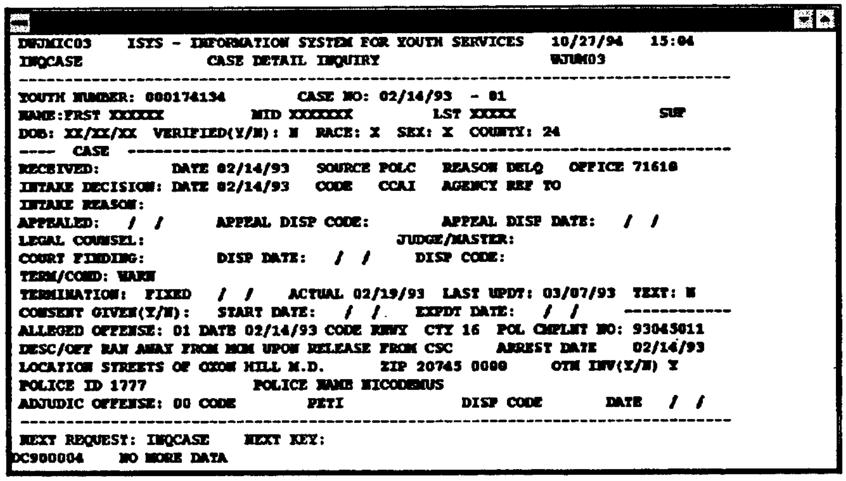
Our Goal

To make recommendations for developing an information system that effectively meets the needs of DJJ, with an emphasis on the user interface design

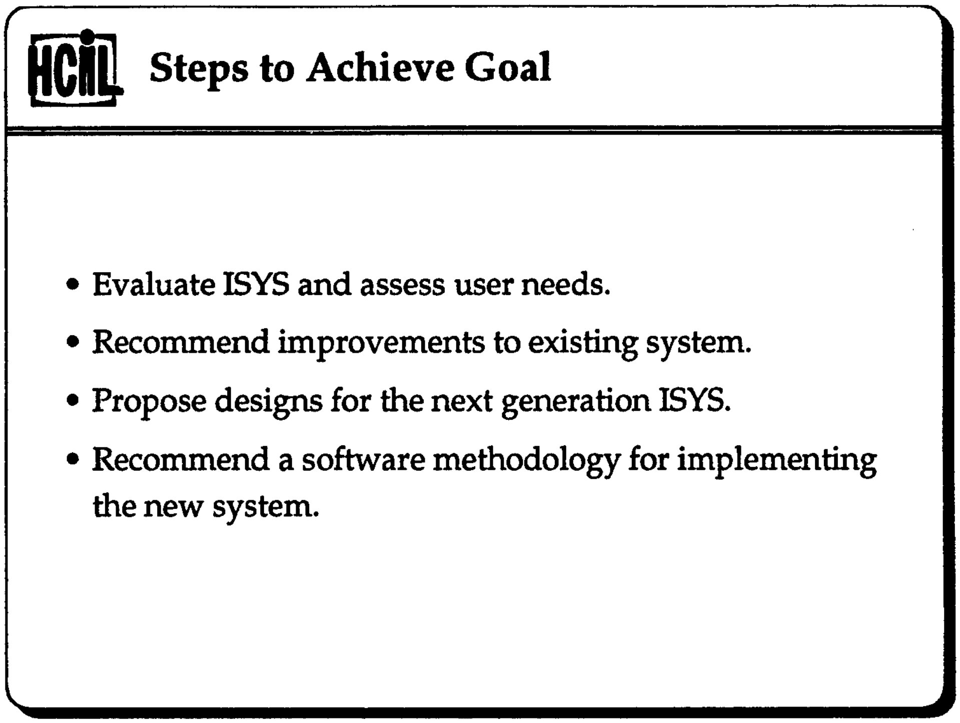
HCIL Introduction to ISYS

- Information System for Youth Services
- terminal based system
- used to process juvenile case referrals in Maryland
- 50,000 cases per year
- approximately 600 users

HCIL Sample ISYS Screen

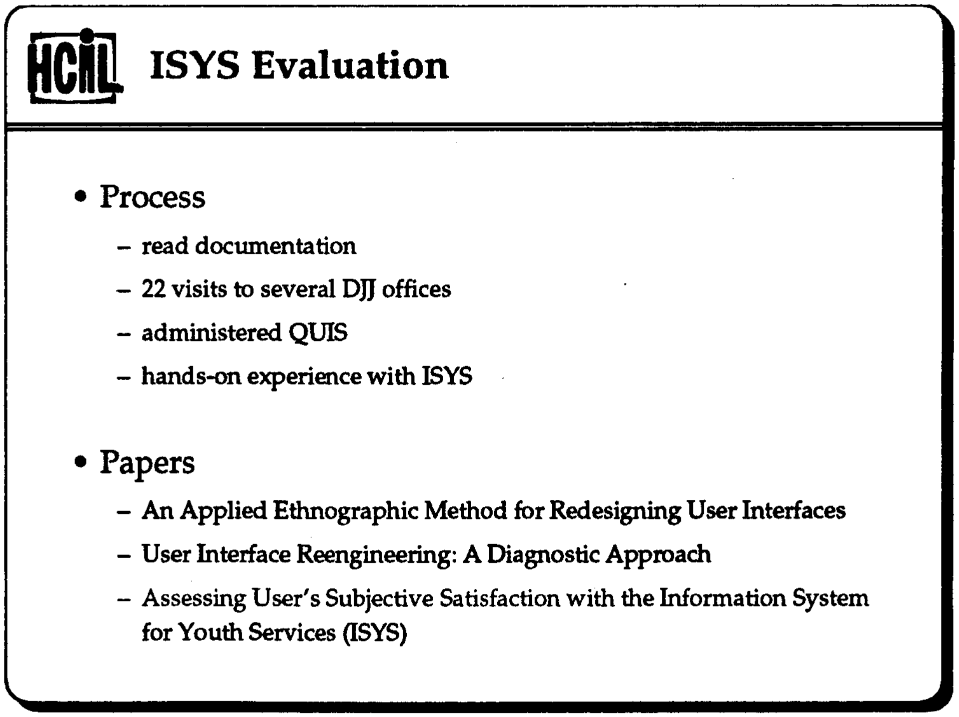


```
DWJMIC03    ISYS - INFORMATION SYSTEM FOR YOUTH SERVICES    10/27/94    15:04
INQCASE                 CASE DETAIL INQUIRY                  WJUM03
---------------------------------------------------------------------------
YOUTH NUMBER: 000174134         CASE NO: 02/14/93  - 01
NAME:FRST XXXXXX            MID XXXXXXX          LST XXXXX                SUF
DOB: XX/XX/XX  VERIFIED(Y/N): N  RACE: X  SEX: X  COUNTY: 24
----  CASE ----------------------------------------------------------------
RECEIVED:           DATE 02/14/93   SOURCE POLC   REASON DELQ   OFFICE 71610
INTAKE DECISION: DATE 02/14/93   CODE    CCAI    AGENCY REF TO
INTAKE REASON:
APPEALED:   / /       APPEAL DISP CODE:          APPEAL DISP DATE:   / /
LEGAL COUNSEL:                               JUDGE/MASTER:
COURT FINDING:        DISP DATE:   / /     DISP CODE:
TERM/COND: WARN
TERMINATION:  FIXED   / /    ACTUAL 02/19/93  LAST UPDT: 03/07/93  TEXT: N
CONSENT GIVEN(Y/N):   START DATE:   / /.   EXPDT DATE:   / /     -----------
ALLEGED OFFENSE: 01 DATE 02/14/93 CODE RNWY  CTY 16  POL CMPLNT NO: 93045011
DESC/OFF RAN AWAY FROM MOM UPON RELEASE FROM CSC     ARREST DATE    02/14/93
LOCATION STREETS OF OXON HILL M.D.        ZIP 20745 0000     OTH INV(Y/N) Y
POLICE ID 1777              POLICE NAME NICODEMUS
ADJUDIC OFFENSE: 00 CODE          PETI                DISP CODE       DATE  / /
---------------------------------------------------------------------------
NEXT REQUEST: INQCASE    NEXT KEY:
DC900004    NO MORE DATA
```



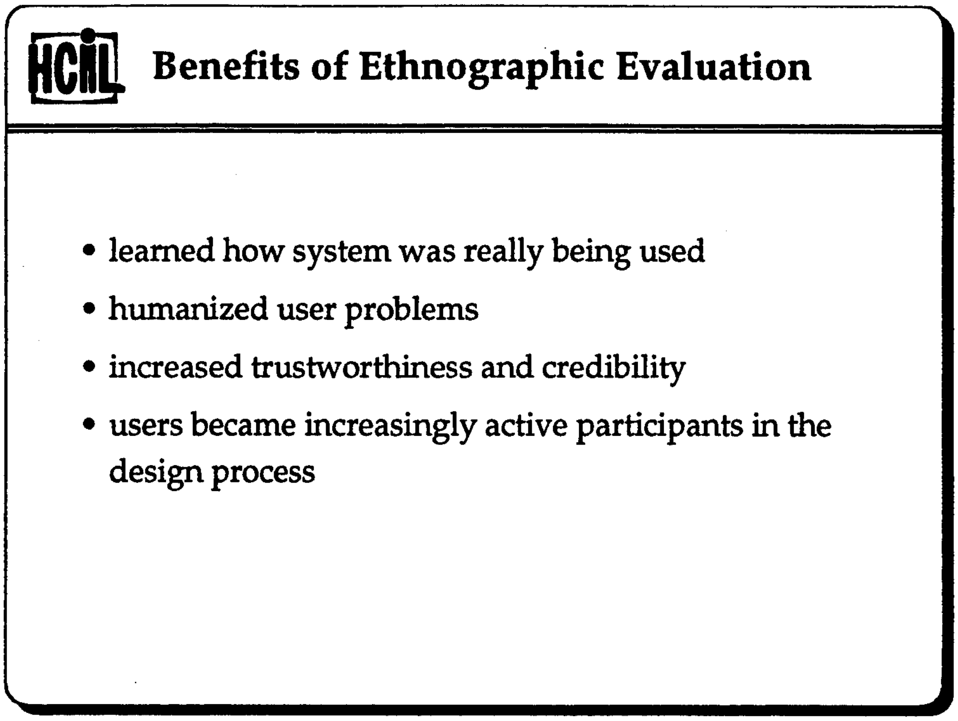
Steps to Achieve Goal

- Evaluate ISYS and assess user needs.
- Recommend improvements to existing system.
- Propose designs for the next generation ISYS.
- Recommend a software methodology for implementing the new system.



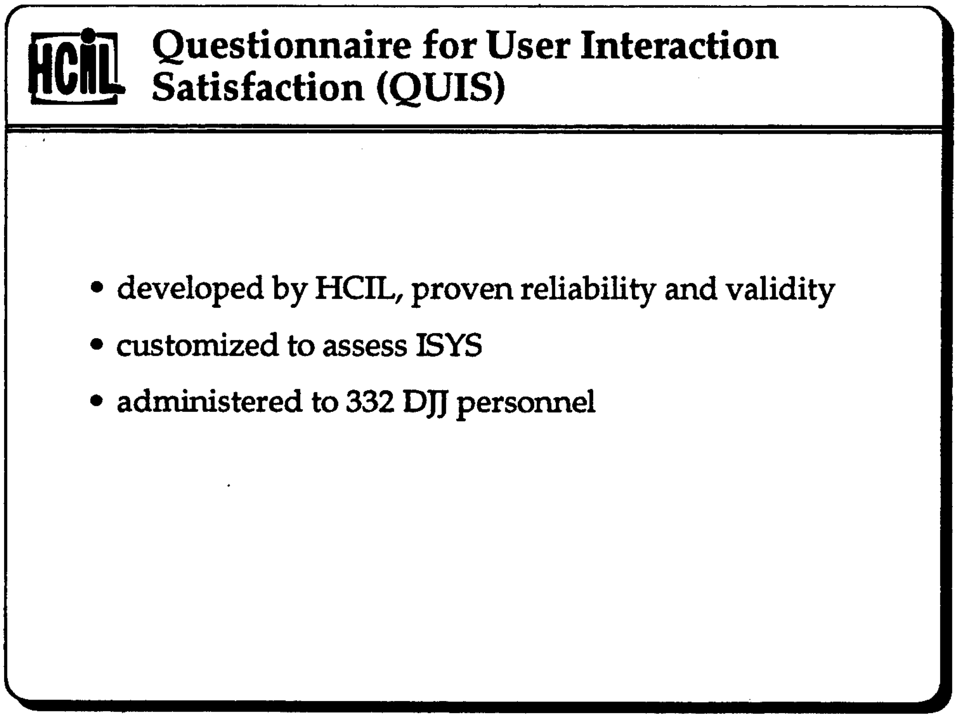
ISYS Evaluation

- Process
  - read documentation
  - 22 visits to several DJJ offices
  - administered QUIS
  - hands-on experience with ISYS
- Papers
  - An Applied Ethnographic Method for Redesigning User Interfaces
  - User Interface Reengineering: A Diagnostic Approach
  - Assessing User's Subjective Satisfaction with the Information System for Youth Services (ISYS)



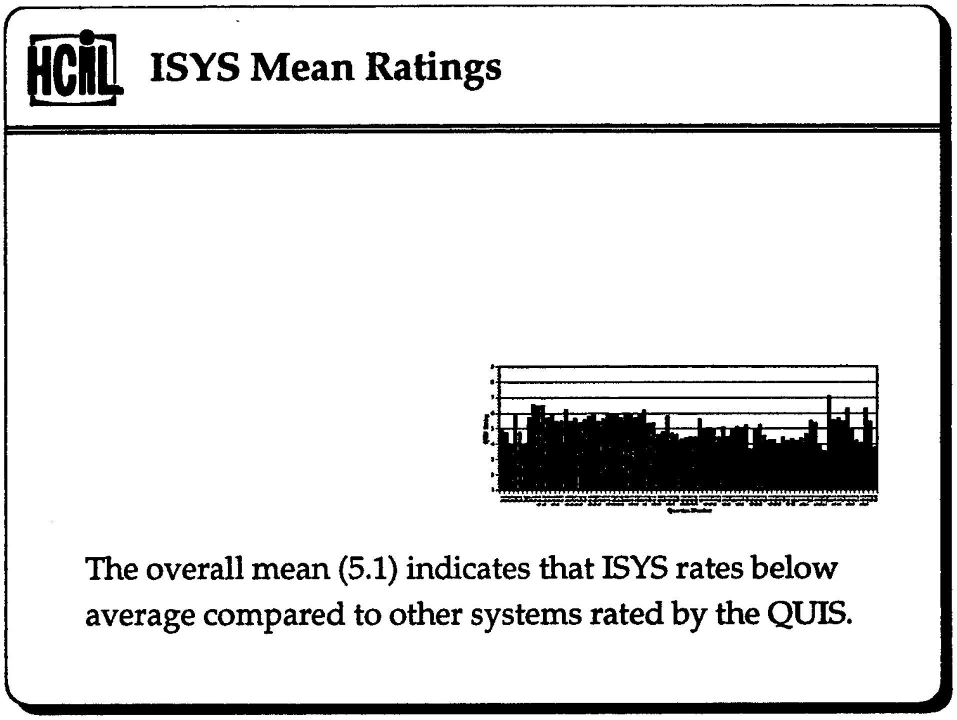
Benefits of Ethnographic Evaluation

- learned how system was really being used
- humanized user problems
- increased trustworthiness and credibility
- users became increasingly active participants in the design process



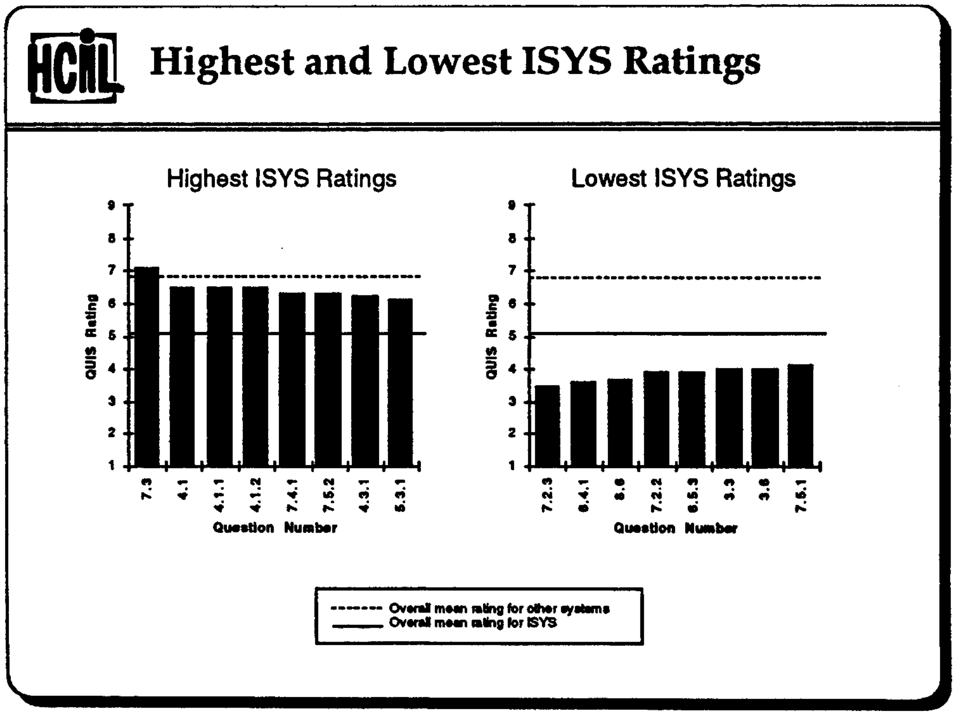
Questionnaire for User Interaction Satisfaction (QUIS)

- developed by HCIL, proven reliability and validity
- customized to assess ISYS
- administered to 332 DJJ personnel

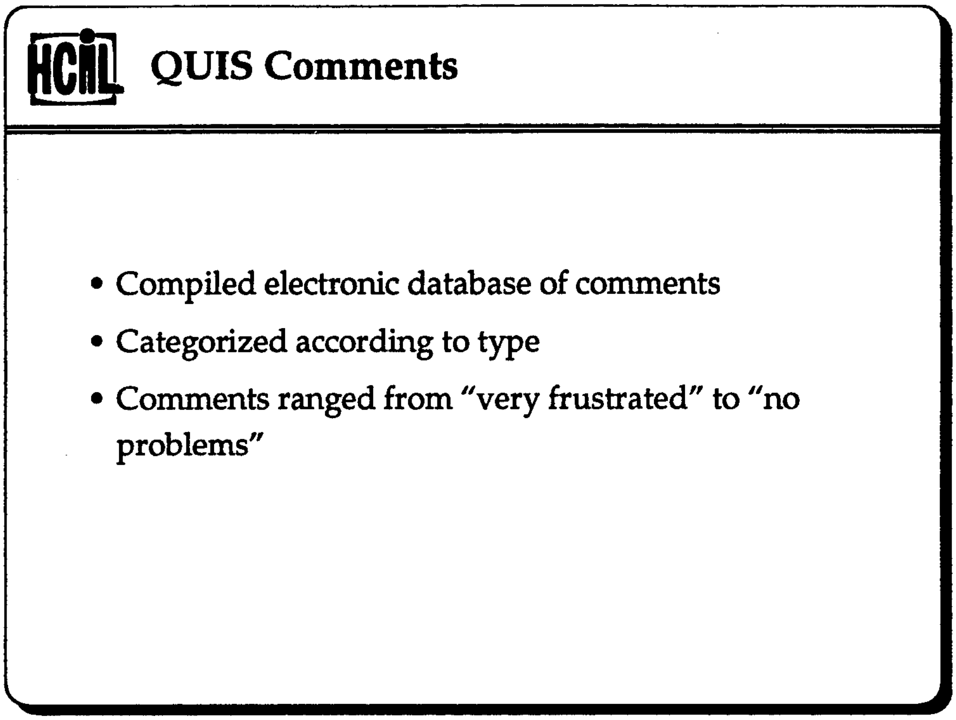


ISYS Mean Ratings

The overall mean (5.1) indicates that ISYS rates below average compared to other systems rated by the QUIS.

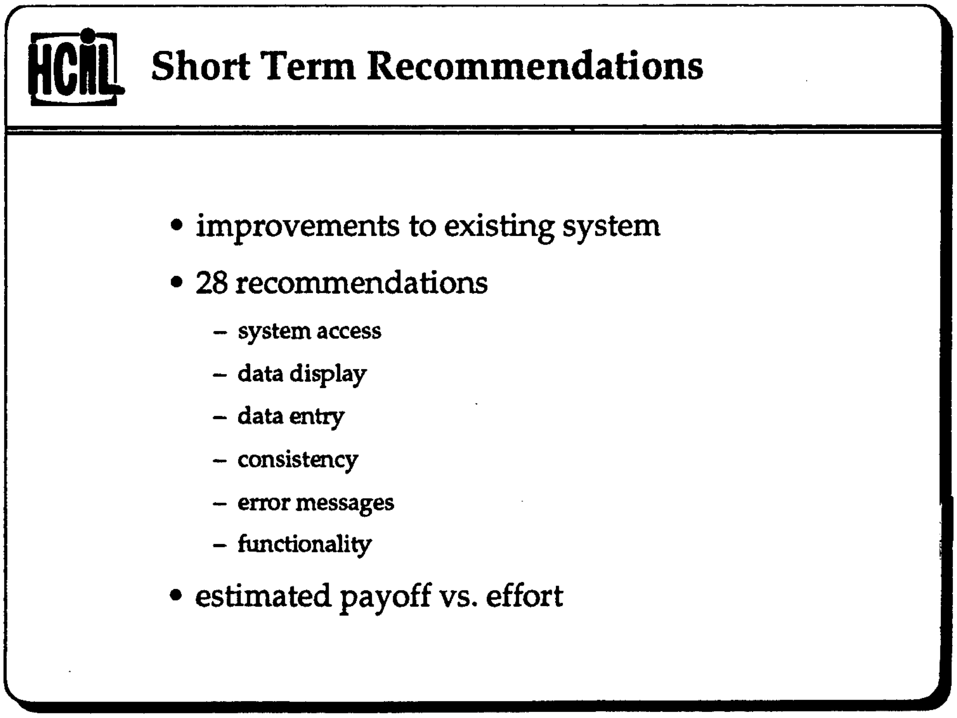


Highest and Lowest ISYS Ratings



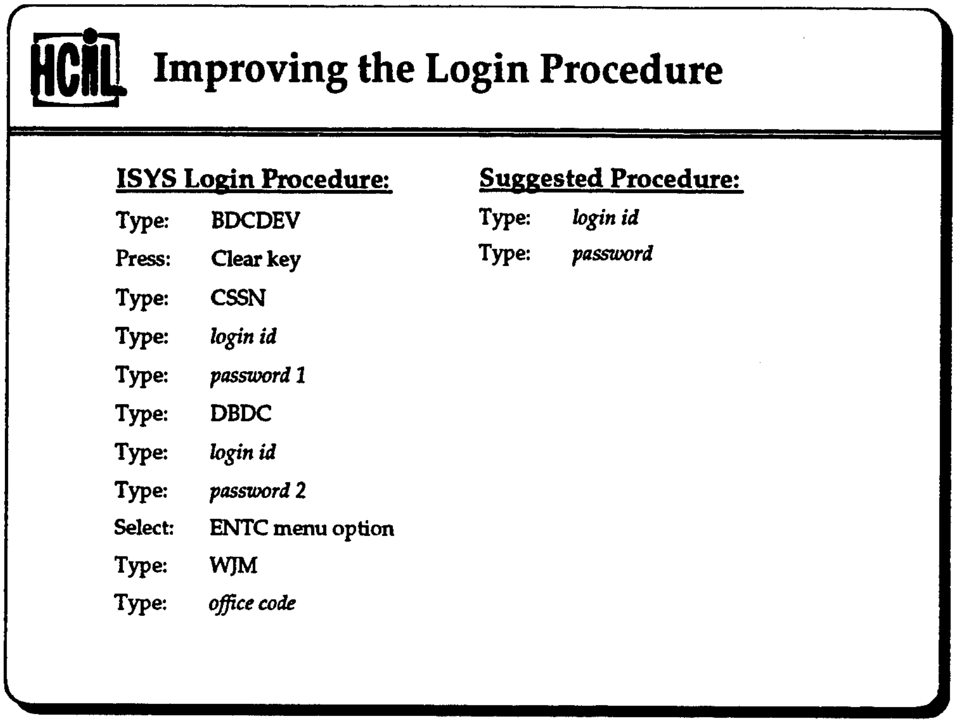
QUIS Comments

- Compiled electronic database of comments
- Categorized according to type
- Comments ranged from "very frustrated" to "no problems"



Short Term Recommendations

- improvements to existing system
- 28 recommendations
  - system access
  - data display
  - data entry
  - consistency
  - error messages
  - functionality
- estimated payoff vs. effort



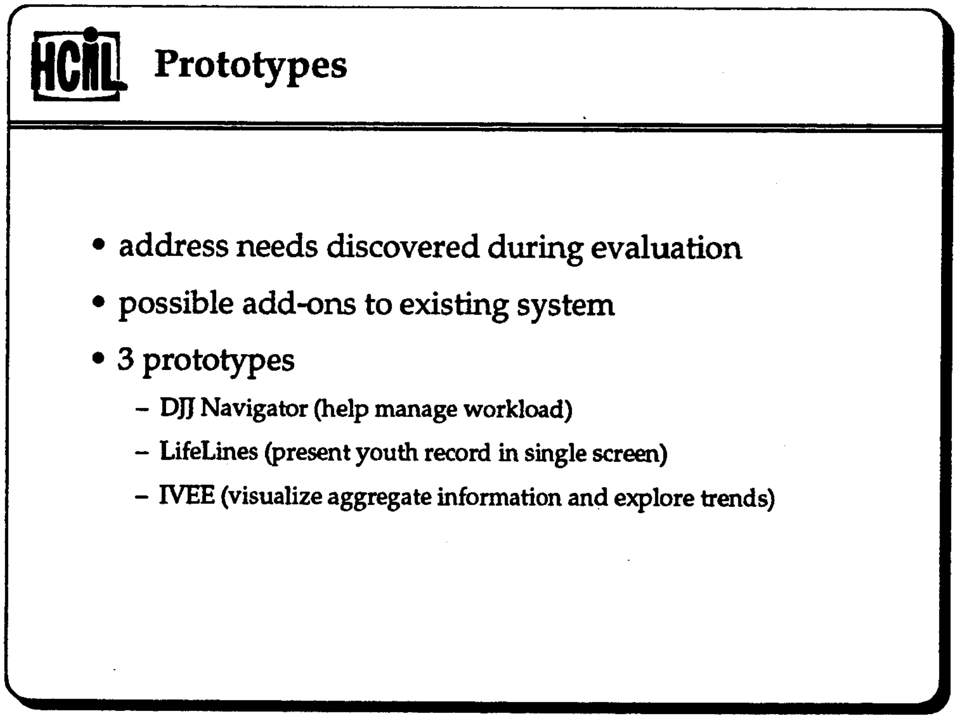
Improving the Login Procedure

ISYS Login Procedure:

Type:	BDCDEV
Press:	Clear key
Type:	CSSN
Type:	*login id*
Type:	*password 1*
Type:	DBDC
Type:	*login id*
Type:	*password 2*
Select:	ENTC menu option
Type:	WJM
Type:	*office code*

Suggested Procedure:

Type:	*login id*
Type:	*password*



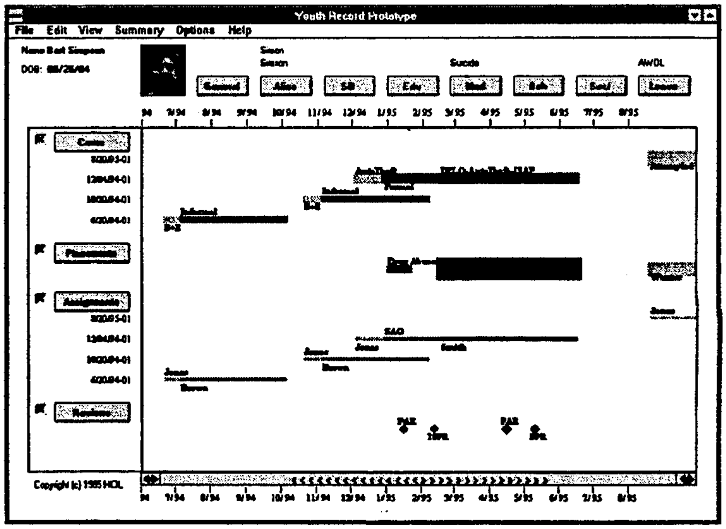
Prototypes

- address needs discovered during evaluation
- possible add-ons to existing system
- 3 prototypes
  - DJJ Navigator (help manage workload)
  - LifeLines (present youth record in single screen)
  - IVEE (visualize aggregate information and explore trends)

LifeLines Overview

- Single screen overview of all cases, placements, assignments and reviews associated with a youth
- Direct access to frequently used ISYS screens
- Zoom on smaller time period
- Highlight relationships
- Potential add-on to current ISYS for PC users
- "Life-Line" addresses the generic problem of providing overview of a person's life (e.g. medical record, resume)

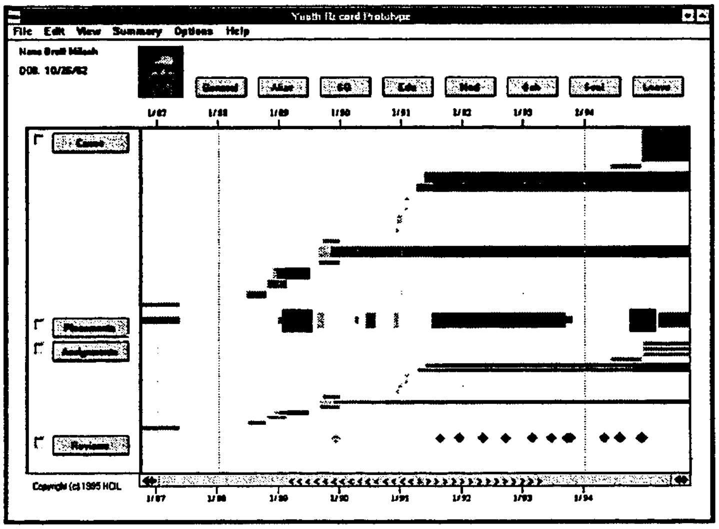
Simple Youth Record



Name Bart Simpson

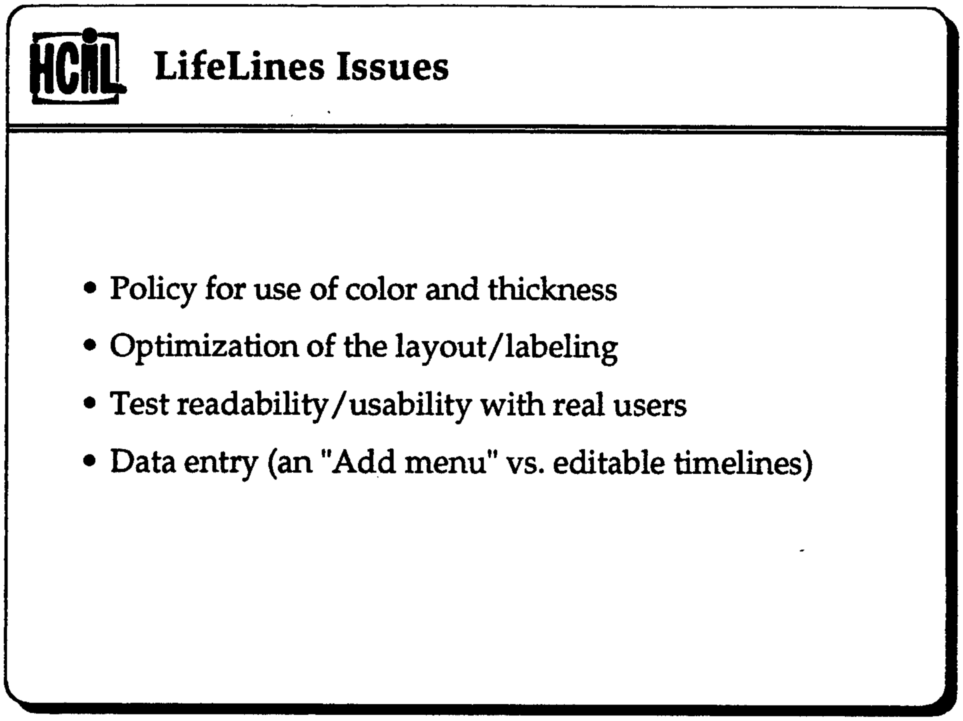
DOB: 08/28/84

Complex Youth Record



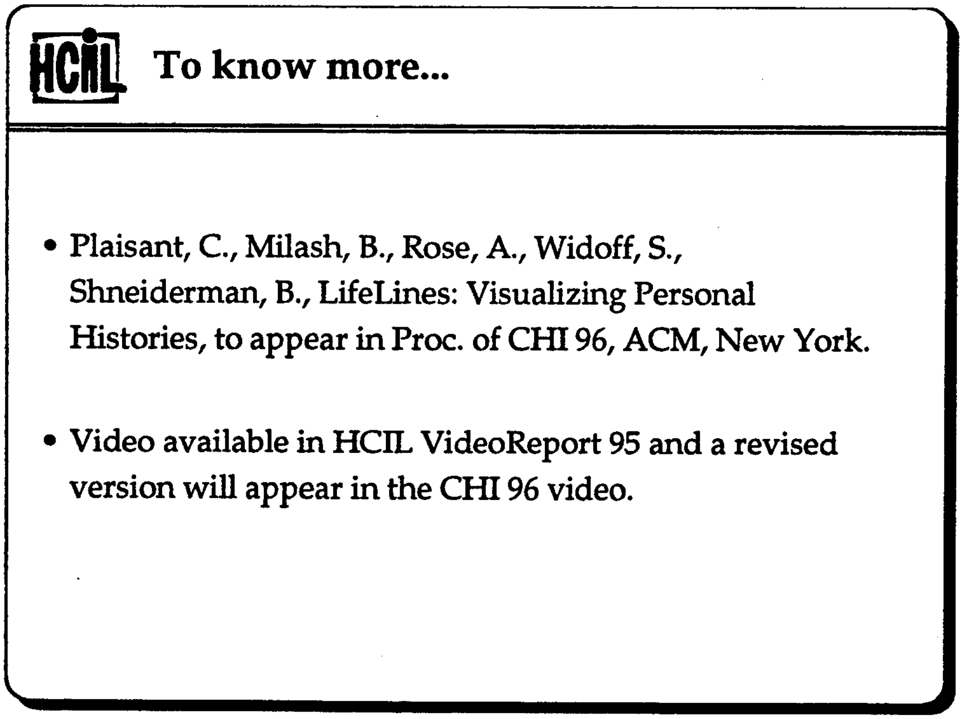
User's Feedback

- Visual Basic prototype
- 60 users (20 minute demo + try + questions)
- Most users enthusiastic
- A few worried about use of color and thickness
- Major pluses: overview + quick access to details
- Many alternate layouts proposed (control panels?)



LifeLines Issues

- Policy for use of color and thickness
- Optimization of the layout/labeling
- Test readability/usability with real users
- Data entry (an "Add menu" vs. editable timelines)



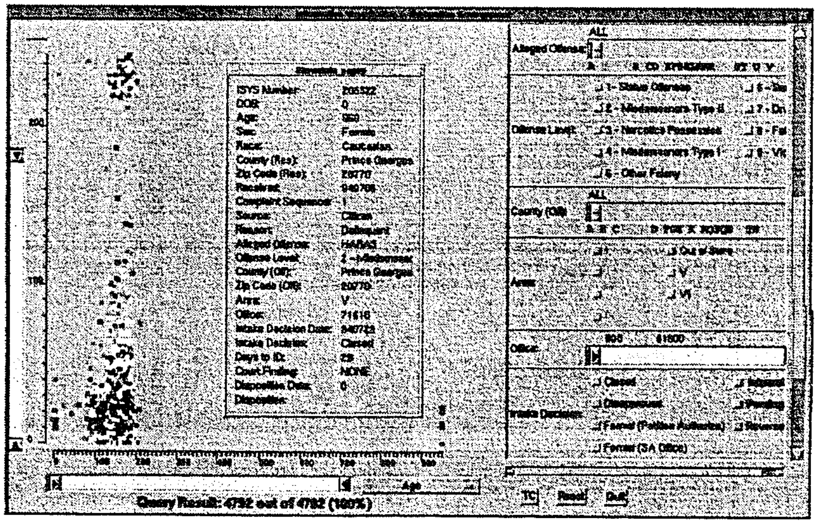
To know more...

- Plaisant, C., Milash, B., Rose, A., Widoff, S., Shneiderman, B., LifeLines: Visualizing Personal Histories, to appear in Proc. of CHI 96, ACM, New York.
- Video available in HCIL VideoReport 95 and a revised version will appear in the CHI 96 video.

IVEE Overview

- Information Visualization & Exploration Environment (IVEE)
- Research tool being developed by Chris Ahlberg and Erik Wistrand of Chalmers University, Sweden
- Dynamic exploration of data trends using zooming and filtering
- Supports generic datasets
- Possible export of subsets to other applications

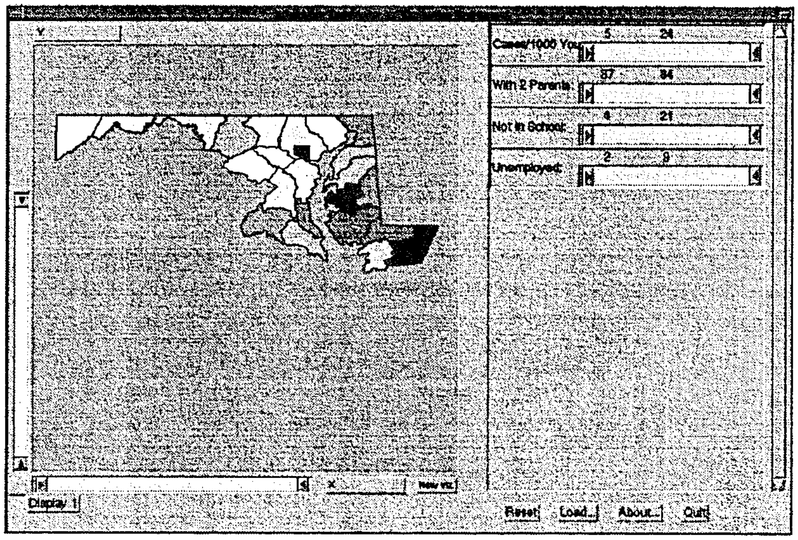
July 1994 Intake Cases



ISYS Number: 205522
DOB: 0
Age: 950
Sex: Female
Race: Caucasian
County (Res): Prince Georges
Zip Code (Res): 20770
Received: 940708
Complaint Sequence: 1
Source: Citizen
Reason: Delinquent
Alleged Offense: HARAS
Offense Level: 2 - Misdemeanor
County (Off): Prince Georges
Zip Code (Off): 20770
Area: V
Office: 71616
Intake Decision Date: 940723
Intake Decision: Closed
Days to ID: 29
Court Finding: NONE
Disposition Date: 0
Disposition:

Query Result: 4792 out of 4792 (100%)

Influences on Delinquency



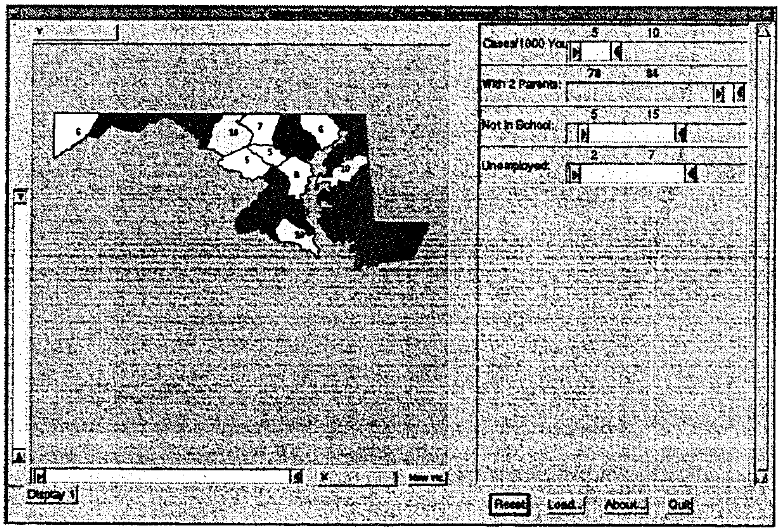
Cases/1000 You: 5 24

With 2 Parents: 57 84

Not in School: 4 21

Unemployed: 2 9

Influence of Two Parent Families

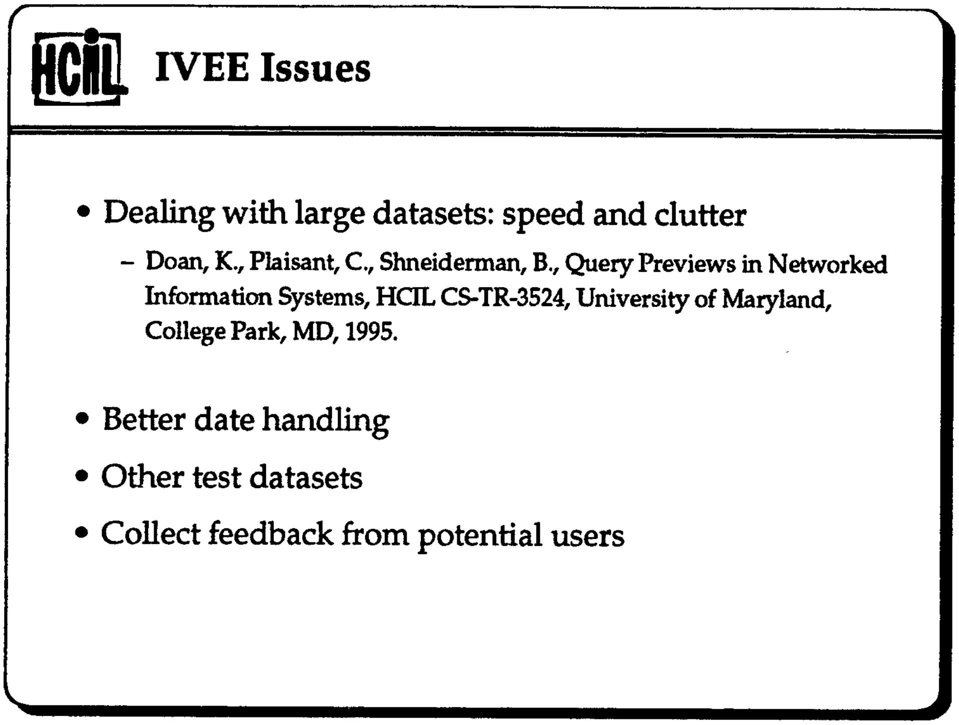


Cases/1000 You: 5 10

With 2 Parents: 78 84

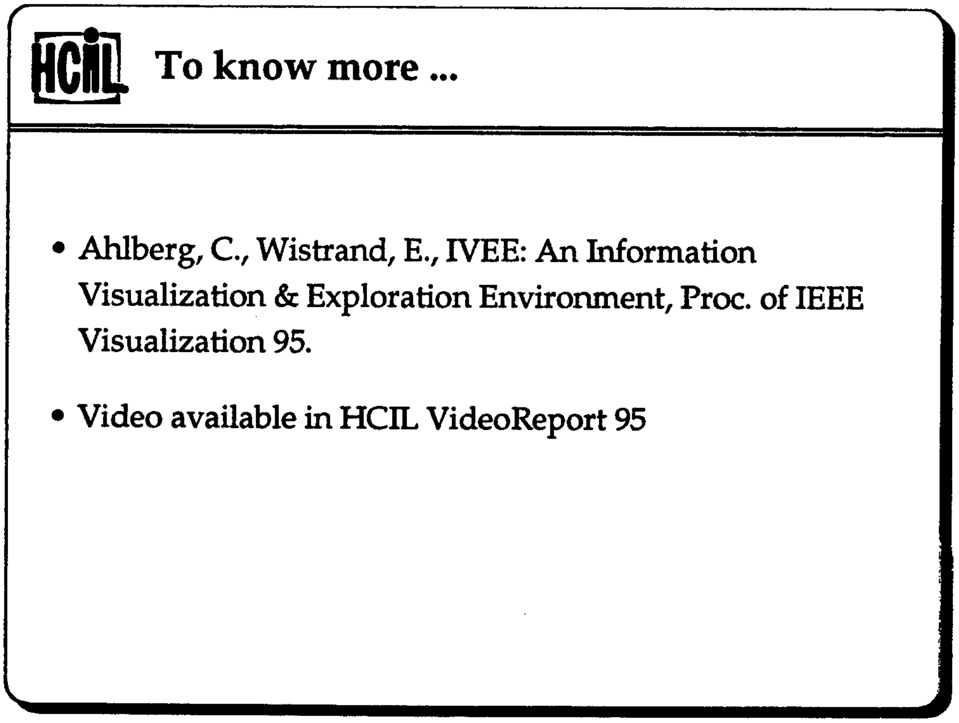
Not in School: 5 15

Unemployed: 2 7



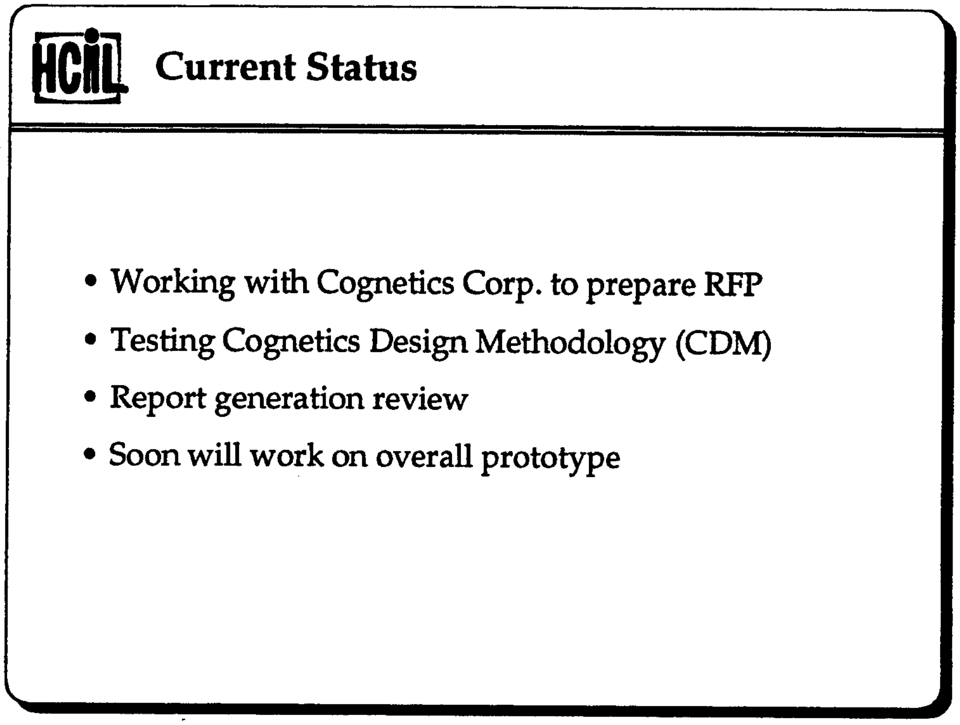
HCIL IVEE Issues

- Dealing with large datasets: speed and clutter
  - Doan, K., Plaisant, C., Shneiderman, B., Query Previews in Networked Information Systems, HCIL CS-TR-3524, University of Maryland, College Park, MD, 1995.
- Better date handling
- Other test datasets
- Collect feedback from potential users



HCIL To know more ...

- Ahlberg, C., Wistrand, E., IVEE: An Information Visualization & Exploration Environment, Proc. of IEEE Visualization 95.
- Video available in HCIL VideoReport 95



Current Status

- Working with Cognetics Corp. to prepare RFP
- Testing Cognetics Design Methodology (CDM)
- Report generation review
- Soon will work on overall prototype

1

Data Reengineering

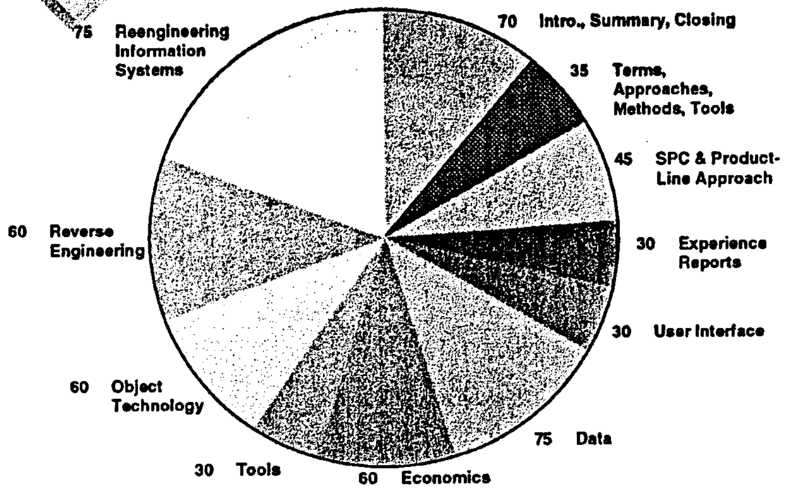
contribution to the
2nd SPC REENGINEERING WORKSHOP:
Approaches to Reengineering for Information Systems

Software Productivity Consortium
Herndon, Virginia December 4 and 5, 1995

Peter Aiken, Ph.D. - Virginia Commonwealth University
paiken@cabell.vcu.edu - 804/828-0174

2

Time Allocation



3

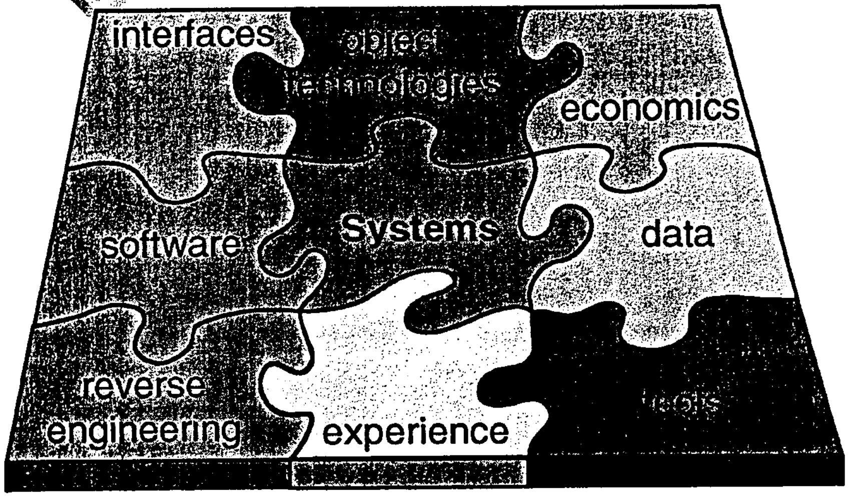
What can be reengineered?

from the program

- Information systems
- User interfaces
- Software
- Data

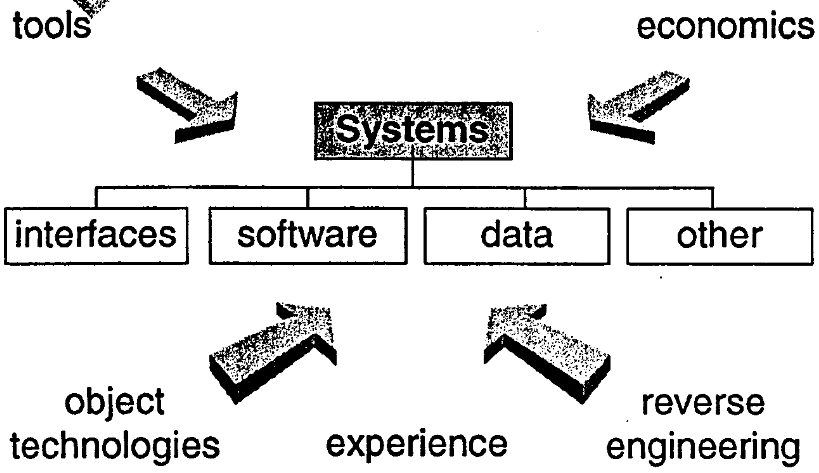
4

How do the pieces fit together?



5

Topical Map



tools

economics

Systems

interfaces

software

data

other

object technologies

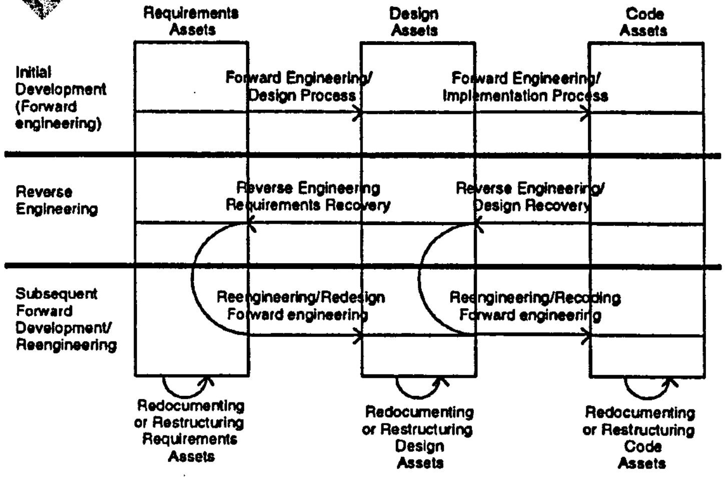
experience

reverse engineering

6

(adapted from Chikofsky and Cross "Reverse Engineering and Design Recovery: A Taxonomy" © 1990 IEEE Software)

What can we learn about reengineering?



Requirements Assets

Design Assets

Code Assets

Initial Development (Forward engineering)

Forward Engineering/ Design Process

Forward Engineering/ Implementation Process

Reverse Engineering

Reverse Engineering Requirements Recovery

Reverse Engineering/ Design Recovery

Subsequent Forward Development/ Reengineering

Reengineering/Redesign Forward engineering

Reengineering/Recoding Forward engineering

Redocumenting or Restructuring Requirements Assets

Redocumenting or Restructuring Design Assets

Redocumenting or Restructuring Code Assets

7

Definition of Data

fact	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	meaning	meaning

Organizational Data Bank

At least one *fact* paired with at least one *meaning*

Appleton [1984]

8

Definition of Data

fact	fact	meaning	meaning
230	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	meaning	meaning
fact	fact	period sales	meaning
fact	fact	meaning	meaning

Organizational Data Bank

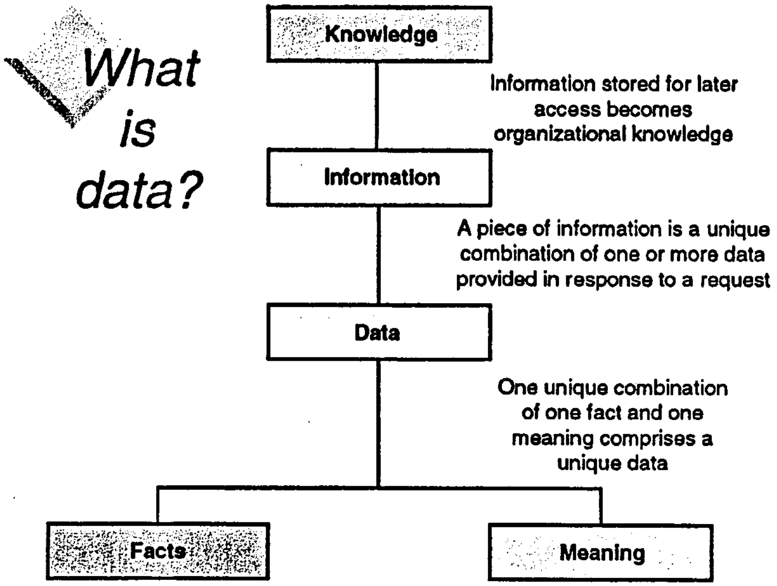
Each unique combination of facts and meanings defines an individual data

Appleton [1984]

9

(Facts, Meaning, Data, and Information Adapted from Appleton 1992)

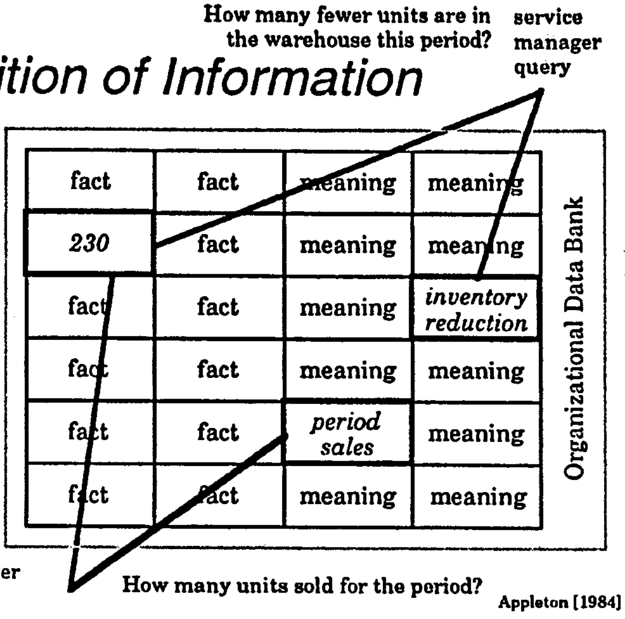
What is data?


Knowledge
Information stored for later access becomes organizational knowledge
Information
A piece of information is a unique combination of one or more data provided in response to a request
Data
One unique combination of one fact and one meaning comprises a unique data
Facts
Meaning

10

Definition of Information

When data is supplied in response to a request, it becomes information


How many fewer units are in the warehouse this period?
service manager query
Organizational Data Bank
sales manager query
How many units sold for the period?

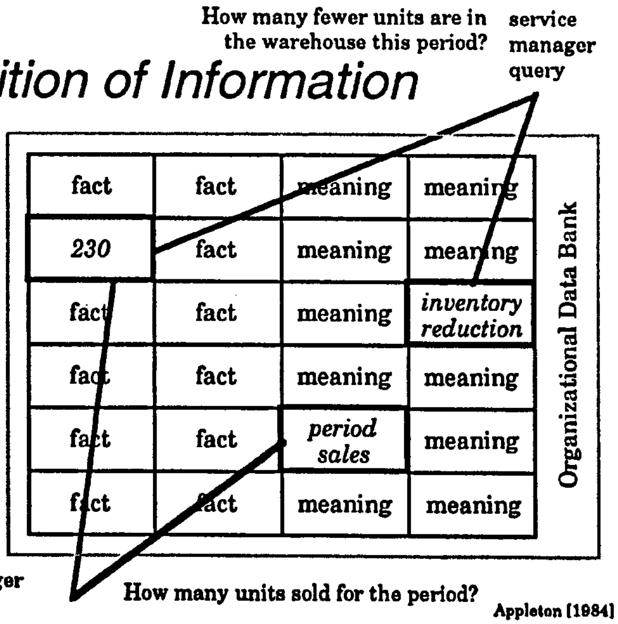
fact	fact	meaning	meaning
230	fact	meaning	meaning
fact	fact	meaning	*inventory reduction*
fact	fact	meaning	meaning
fact	fact	*period sales*	meaning
fact	fact	meaning	meaning

Appleton [1984]

11

Definition of Information

Different facts and meanings can be combined into data and supplied as information in response to different queries


How many fewer units are in the warehouse this period?
service manager query
Organizational Data Bank
sales manager query
How many units sold for the period?

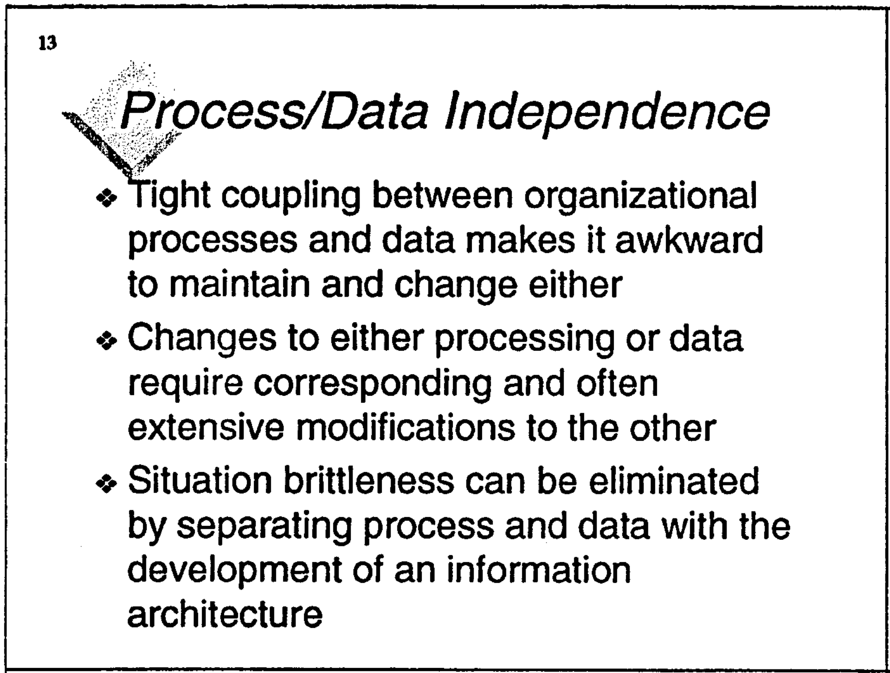
fact	fact	meaning	meaning
230	fact	meaning	meaning
fact	fact	meaning	*inventory reduction*
fact	fact	meaning	meaning
fact	fact	*period sales*	meaning
fact	fact	meaning	meaning

Appleton [1984]

12

Data Reengineering Goals

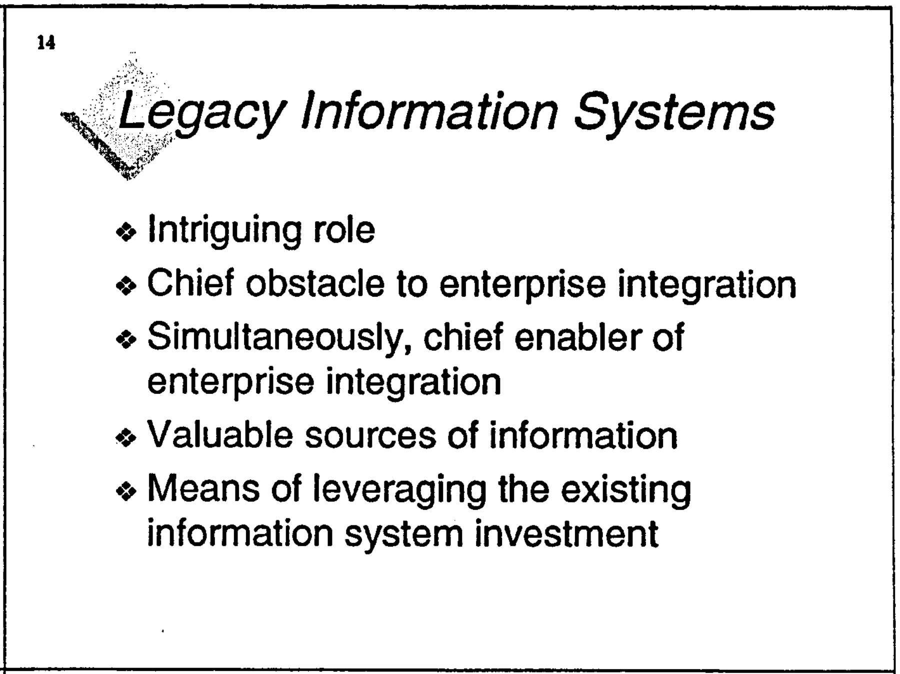
1. difficult to forecast future information needs - stored information needs to be flexible and adaptable
2. data independence is a goal
3. leverage economies of scale by managing lot of information with a relatively small amount of data



13

Process/Data Independence

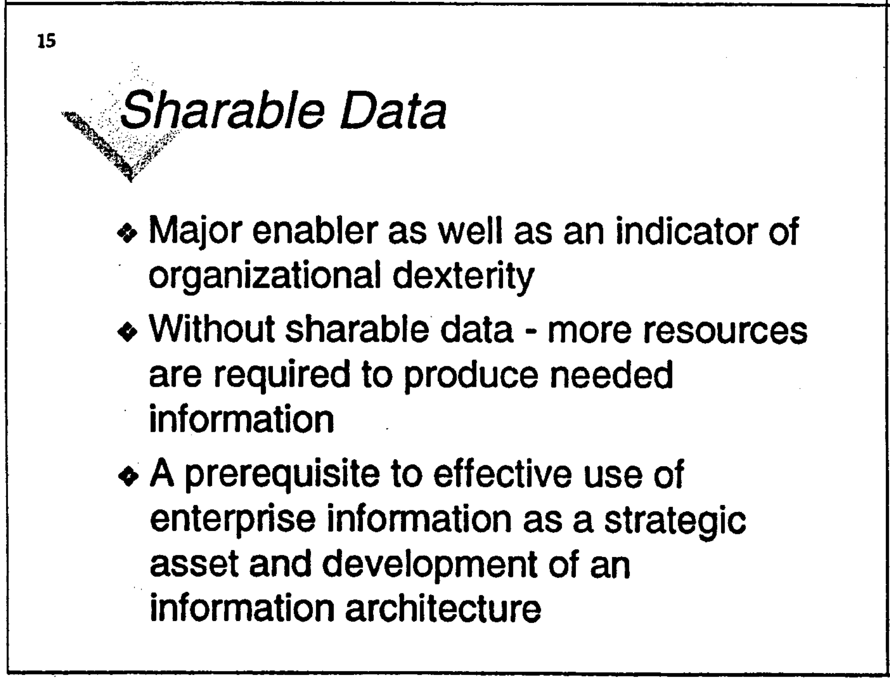
- Tight coupling between organizational processes and data makes it awkward to maintain and change either
- Changes to either processing or data require corresponding and often extensive modifications to the other
- Situation brittleness can be eliminated by separating process and data with the development of an information architecture



14

Legacy Information Systems

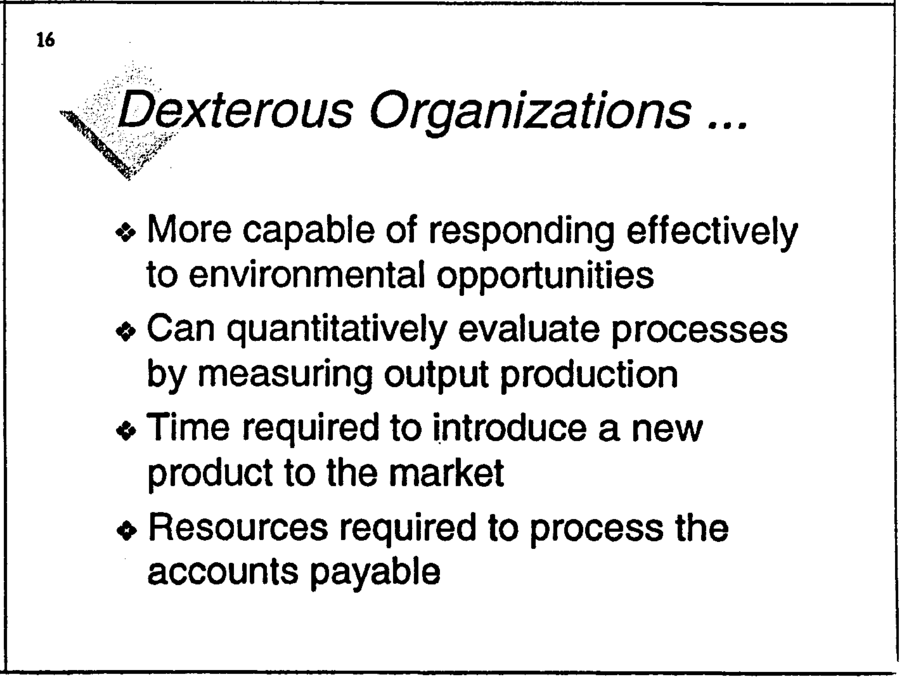
- Intriguing role
- Chief obstacle to enterprise integration
- Simultaneously, chief enabler of enterprise integration
- Valuable sources of information
- Means of leveraging the existing information system investment



15

Sharable Data

- Major enabler as well as an indicator of organizational dexterity
- Without sharable data - more resources are required to produce needed information
- A prerequisite to effective use of enterprise information as a strategic asset and development of an information architecture



16

Dexterous Organizations ...

- More capable of responding effectively to environmental opportunities
- Can quantitatively evaluate processes by measuring output production
- Time required to introduce a new product to the market
- Resources required to process the accounts payable

17

Dexterous Organizations ...

- ❖ Knowledge of capabilities
- ❖ Useless if not applied in appropriate contexts with reasonable expectations
- ❖ Example: facility of major airline reservation systems to handle:
  - – tens of millions of monthly transactions
  - – two thousand messages per second
  - – 500,000 new passenger name records daily [Hopper 1990]

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Shared Data

- ❖ Enterprise integration is impossible without integrated enterprise information
- ❖ Shared data is typified by organizational ability to use information as a strategic asset
- ❖ However, assets are useless without knowledge of the asset characteristics

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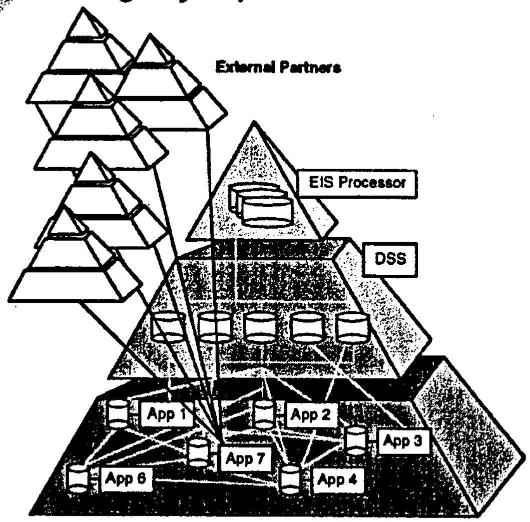
Typical Legacy Operational Environment



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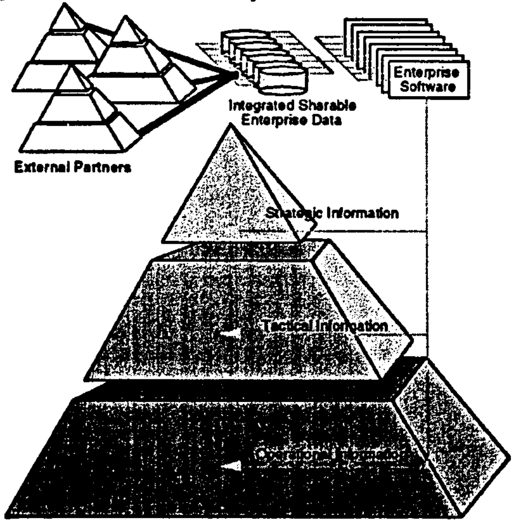
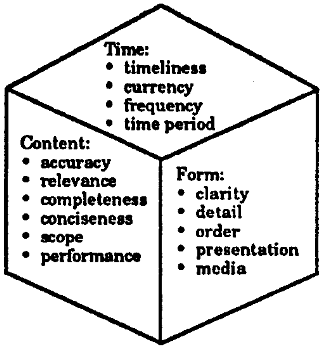
Integrated Enterprise Information



21

Attributes of Information Quality

(adapted from [O'Brien 1993])



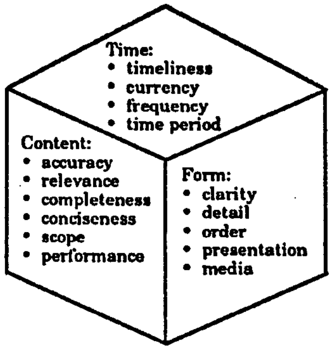
Time Dimension

✦ Timeliness	provided when it is needed
✦ Currency	up-to-date when it is provided
✦ Frequency	provided as often as needed
✦ Time Period	be provided about past, present, and future time periods

22

Attributes of Information Quality

(adapted from [O'Brien 1993])



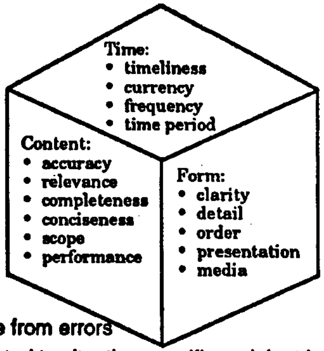
Form Dimension

✦ Clarity	provided in a form that is easy to understand
✦ Detail	provided in detail or summary form
✦ Order	arranged in a predetermined sequence
✦ Presentation	presented in narrative, numeric graphic or other forms
✦ Media	provided on printed paper documents, video displays, or etc.

23

Attributes of Information Quality

(adapted from [O'Brien 1993])



Content Dimension

✦ Accuracy	free from errors
✦ Relevance	related to situation specific recipient information needs
✦ Completeness	all the information that is needed should be provided
✦ Conciseness	only the information that is needed should be provided
✦ Scope	broad/narrow, or internal/focus
✦ Performance	measured to reveal performance

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Winchester House

- compares information systems portfolios to the Winchester House -- a building where construction
- "continued 24 hours a day, seven days a week, month after month, year after year–for 38 years! ... highlights of the tour (now given) are such odd features as stairways that rise into ceilings, doors and windows blocked by walls, more passageways and halls than rooms, a four story chimney that falls short of the roof, and many rooms serving the same purpose."

Enterprise Architecture Planning [Spewack 1993]

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Winchester House (example)

In this example, a person walks down 7 steps and up 11, gaining only 4 steps but apparently satisfying a mystical need for Sarah Winchester

Winchester Mystery House [Roberts]

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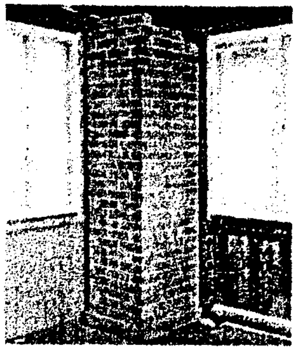
Winchester House (example)



This strange chimney begins on the ground floor and goes up through 4 floors ... only to stop just inches short of the 4th story roof ... making the 3 or 4 fireplaces that connect to it absolutely useless.

Winchester Mystery House [Roberts]

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Winchester House

- No overall set of blueprints showed what Mrs. Winchester wanted her house to be.
- Similarly, most systems organizations have no overall blueprints for the data, systems and technology needed to support the business.

Enterprise Architecture Planning [Spewack 1993]

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National Cathedral Development

- spanned eighty years and four generations of craftsman - 'Could it have been done without the blueprints?'
- Similarly, after the passage of time - information system:
- "plans and documentation ... are poor or non-existent, and the original designers and craftsmen are no longer available. The result is increasing maintenance costs and decreasing programmer productivity-a situation that is inefficient, wasteful and costly to our businesses. "

[Connall & Burns 1993]

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Architectures Defined

- Architectures are plans, guiding the transformation of strategic organizational information needs into specific information systems development projects. All organizations have architectures - some are better understood and documented than others.

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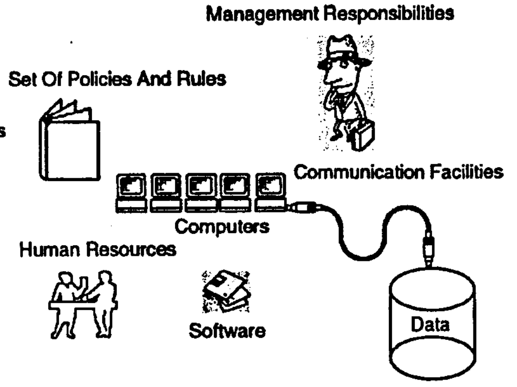
Corporate Data Architecture Defined

- How and why do the components interact?
- Where do they go?
- When are they needed?
- Why and how will the changes be implemented?
- What should be managed organization-wide and what should be managed locally?
- What standards should be adopted?
- What vendors should be chosen?
- What rules should govern the decisions?
- What policies should guide the process?



(Adapted from [Allen & Boynton 1991])

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Data Architectures Defined

- Blueprints/master plans for accomplishing data administration goals and objectives
- Information maintained by data administration in a data architecture includes the:
- sources and uses of data;
- creation and use of data by specific processes; and
- various organizational communication capabilities for delivering the information among data collections and its uses.

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Zachman Framework

- Describes data architectures as integrated information collections pertaining to information systems development
- Key is to organize information according to different perspectives
- Views range from contextual to implementation specific data, function, and communication specifications

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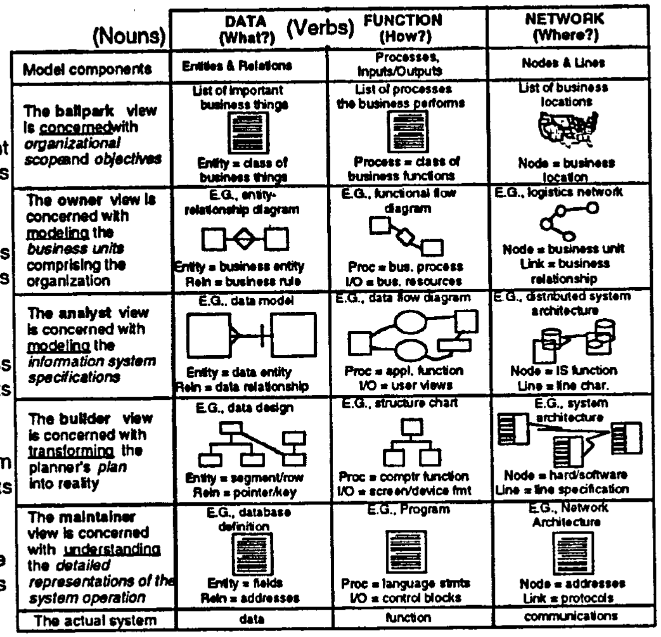
Zachman Framework



	(Nouns)	DATA (What?) (Verbs)	FUNCTION (How?)	NETWORK (Where?)
	Model components	Entities & Relations	Processes, Inputs/Outputs	Nodes & Lines
Investment Decisions	The ballpark view is <u>concernedwith</u> *organizational scopeand objectives*	List of important business things Entity = class of business things	List of processes the business performs Process = class of business functions	List of business locations Node = business location

Business Entities	The owner view is concerned with modeling the *business units* comprising the organization	E.G., entity-relationship diagram
		Entity = business entity
		Reln = business rule
			E.G., functional flow diagram
			Proc = bus. process
			I/O = bus. resources
				E.G., logistics network
				Node = business unit
				Link = business relationship

Business Requirements	The analyst view is concerned with modeling the *information system specifications*	E.G., data model
		Entity = data entity
		Reln = data relationship
			E.G., data flow diagram
			Proc = appl. function
			I/O = user views
				E.G., distributed system architecture
				Node = IS function
				Line = line char.

System Requirements	The builder view is concerned with transforming the planner's *plan* into reality	E.G., data design
		Entity = segment/row
		Reln = pointer/key
			E.G., structure chart
			Proc = comptr function
			I/O = screen/device fmt
				E.G., system architecture
				Node = hard/software
				Line = line specification

Software Requirements	The maintainer view is concerned with understanding the *detailed representations of the system operation*	E.G., database definition
		Entity = fields
		Reln = addresses
			E.G., Program
			Proc = language stmts
			I/O = control blocks
				E.G., Network Architecture
				Node = addresses
				Link = protocols

(Zachman 1987)	The actual system	data	function	communications

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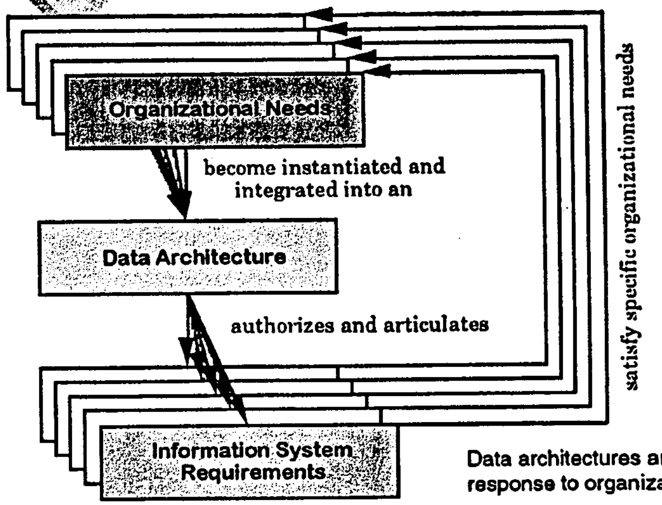
Data Architecture Development



Organizational Needs

become instantiated and integrated into an

Data Architecture

authorizes and articulates

Information System Requirements

satisfy specific organizational needs

Data architectures are developed in response to organizational needs

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Data Architecture Development

- The successful development of a organizational data architecture requires a degree of information system development:
- more often spoken about than sought after and
- more often sought after than achieved.
- Strategic planning without the benefit of a data architecture is just a ritual rain dance.

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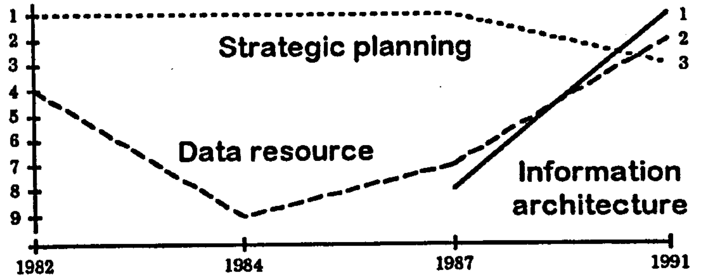
Organizational Data Administration



Relative Importance of Data, Architecture and Planning Issues Identified by Information Systems Professionals (adapted from [Neiderman et. al 1991)

37

Organizational Data Administration

- developing and maintaining standard data products and models;
- developing and maintaining an organizational data bank for storing and integrating organizational data assets;
- encouraging the use of common procedures and tools; and
- providing education, training, and consultation services to the

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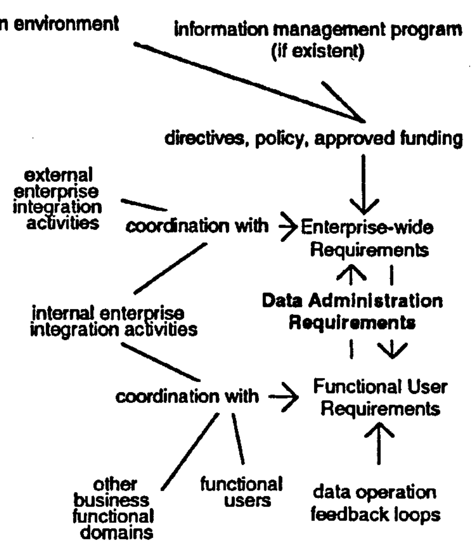
Organizational Data Administration


(by default) legacy information environment
information management program (if existent)
directives, policy, approved funding
external enterprise integration activities
coordination with
Enterprise-wide Requirements
Data Administration Requirements
internal enterprise integration activities
coordination with
Functional User Requirements
other business functional domains
functional users
data operation feedback loops

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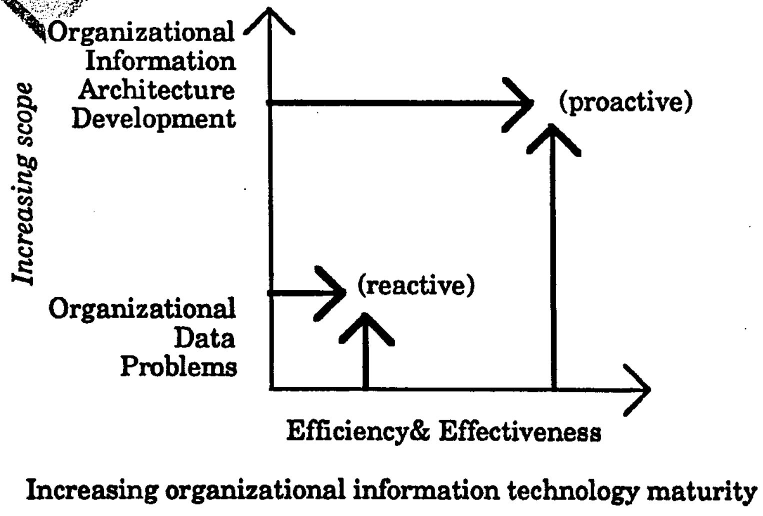
Data Administration Tasks


Increasing scope
Organizational Information Architecture Development
Organizational Data Problems
(proactive)
(reactive)
Efficiency& Effectiveness
Increasing organizational information technology maturity

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4 Types of Reengineering

- Data Reengineering
- Existing data are inventoried
- Structured into an architecture, and evolved into more flexible and process independent support for business processes

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4 Types of Reengineering

Business Process Reengineering

- ❖ Inventories current supported business processes
- ❖ Corrects locally optimized process and
- ❖ Focus them on organization objectives

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4 Types of Reengineering

Software Reengineering

- ❖ Reengineer selected software applications
- ❖ To obtain targeted software assets
- ❖ To obtain design assets for reuse
- ❖ Some for both reasons

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4 Types of Reengineering

Infrastructure Reengineering

- ❖ Evaluate technological infrastructure for future opportunities
- ❖ Matching organizational needs with solutions facilitating organizational dexterity
- ❖ Solving problems such as removing barriers to inter-operability

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Procedure Overview

<u>Phase</u>

1 What do you currently have?

Reverse engineer existing assets by "as is" modeling

2 What would you like to have?

Develop an architectural plan by modeling "to be" systems

3 What do you need?

Identify the gaps

4 How do will you get there?

Develop solutions to close the gaps and implement

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Enterprise Integration Defined

- 'effective and efficient organizational functioning'
- improving the overall performance of large, complex systems
- processing efficiency, unit responsiveness, perceived quality, and product differentiation
- facilitating the interaction among organizations, individuals, and systems
- Proceedings of the First International Enterprise Integration Modeling Conference, 1992

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Enterprise Integration Defined

- Enterprise integration efforts
  - facilitate the interaction among organizations, individuals, and systems
- Enterprise integration can be defined as
  - a state of organizational dexterity
  - combined with organizational awareness of that dexterity

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Integration Perspectives

	Data	Process	Software	Infrastructure
"As-is" analysis (establish base line)	What data assets do we currently have?	What processes are we currently supporting?	What software applications are we currently supporting	What is our technological infrastructure base?
"To-be" analysis (radical change)	What data assets should we be maintaining?	What processes should be supported?	How should our software assets be employed?	What technological infrastructure will be required in the future?
Continuous implementation activities	How will we get from our current state to our desired state?	How are we going to implement the new processes?	Transforming our software assets to the desired states?	How are we going to implement the required infra-structure?

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Integration Perspectives

	Data	Process	Software	Infrastructure
"As-is" analysis base line)	What data assets do we currently have?	What processes are we currently supporting? structure?	What software applications are we currently supporting	What is our technological infrastructure base?
analysis (radical change)	What data assets should we be maintaining?	What processes should be supported?	How should our software assets be employed?	technological infrastructure will be required in the future?
Continuous implementation activities	How will we get from our current state to our desired	How are we going to implement the new	Transforming our software assets to the desired states?	How are we going to implement the required infra-structure?

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Integration Perspectives

	Data	Process	Software	Infrastructure
Reverse Engineering Activities	Data Reverse Engineering	Business Process Reengineering	Software Reverse Engineering	Infrastructure Evaluation
Architecture Engineering Activities	Data Architecture Engineering		Software Architecture Development	Infrastructure Development/ Customization
Forward Engineering Activities	Data Evolution		Application Software Development	Infrastructure Modernization

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Integration Perspectives

	Data	Process	Software	Infrastructure
Reverse Engineering Activities	Data Reverse Engineering	Business Process Reengineering	Software Reverse Engineering	Infrastructure Evaluation
Architecture Engineering Activities	Data Architecture Engineering		Software Architecture Development	Infrastructure Development/ Customization
Forward Engineering Activities	Data Evolution		Application Software Development	Infrastructure Modernization

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Procedure Overview

Phase

1 What do you currently have?

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Identify the gaps

4 How do will you get there?

Develop solutions to close the gaps and implement

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Phase Activity Relationships

Phase	Name	Phase Description	Associated Processes
1	Base Line Development Activities	The process of establishing an information base for further study and evaluation	• Data Reverse Engineering • Infrastructure Evaluation • "As-Is" Process Reverse Engineering
2	Architecture Planning Activities	Creation of plans guiding the subsequent development processes.	• "To-Be" Process Engineering • Data Architecture Engineering • Infrastructure Development • Software Architecture Development
3	Architecture Implementation Activities	Organization create working products based on the reengineered organizational architecture products.	• Infrastructure Customization • Data Evolution • Software Reverse Engineering
4	Architecture Population Activities	Create products capable of taking advantage of the features of the newly developed architecture.	• Infrastructure Modernization • Application Software Development

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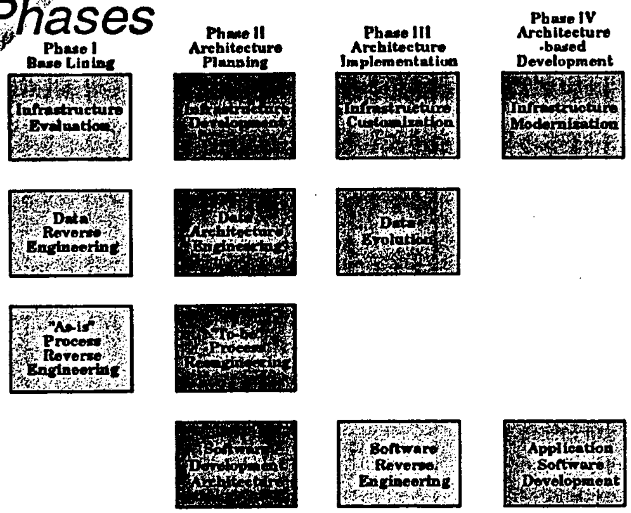
Activities Organized into Phases


Phase I
Base Lining
Phase II
Architecture
Planning
Phase III
Architecture
Implementation
Phase IV
Architecture
-based
Development
Infrastructure Evaluation
Infrastructure Development
Infrastructure Customization
Infrastructure Modernization
Data Reverse Engineering
Data Architecture Engineering
Data Evolution
"As-is" Process Reverse Engineering
"To-be" Process Reengineering
Software Development Architecture
Software Reverse Engineering
Application Software Development

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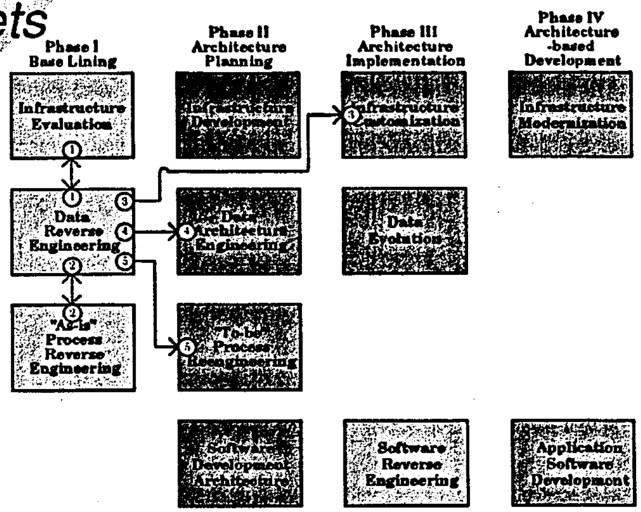
5-An inventory of existing data assets


Phase I
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Infrastructure Evaluation
Infrastructure Development
Infrastructure Customization
Infrastructure Modernization
Data Reverse Engineering
Data Architecture Engineering
Data Evolution
"As-is" Process Reverse Engineering
"To-be" Process Reengineering
Software Development Architecture
Software Reverse Engineering
Application Software Development
1
2
3
4
5

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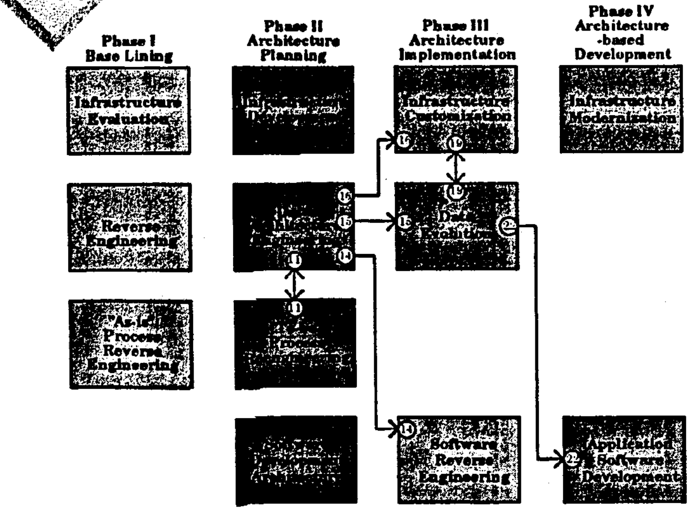
22-Guidelines and requirements for application software development


Phase I
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Implementation
Phase IV
Architecture
-based
Development
Infrastructure Evaluation
Infrastructure Customization
Infrastructure Modernization
Reverse Engineering
"As-is" Process Reverse Engineering
Data Evolution
Software Reverse Engineering
Application Software Development
11
14
15
16
22

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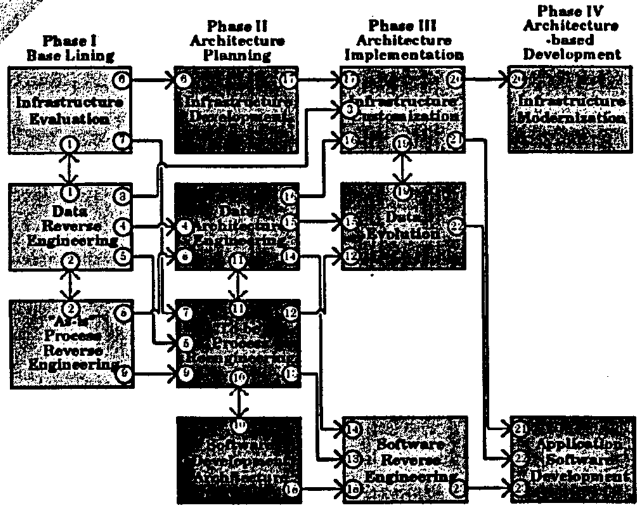
Activity/Phase Dependencies


Phase I
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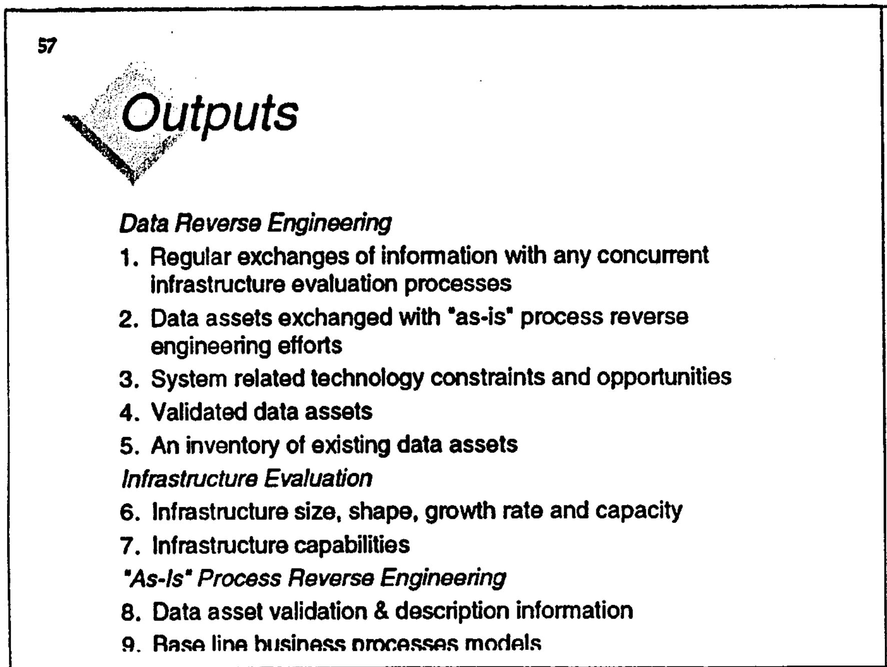
Software Reverse Engineering
Application Software Development



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Outputs

Data Reverse Engineering

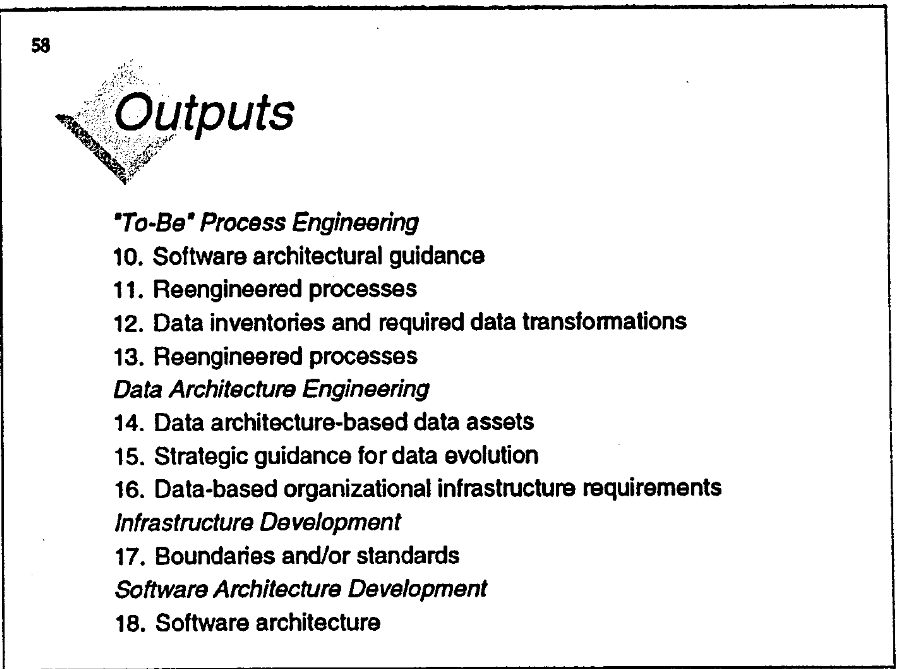
1. Regular exchanges of information with any concurrent infrastructure evaluation processes
2. Data assets exchanged with "as-is" process reverse engineering efforts
3. System related technology constraints and opportunities
4. Validated data assets
5. An inventory of existing data assets

Infrastructure Evaluation

6. Infrastructure size, shape, growth rate and capacity
7. Infrastructure capabilities

"As-Is" Process Reverse Engineering

8. Data asset validation & description information
9. Base line business processes models



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Outputs

"To-Be" Process Engineering

10. Software architectural guidance
11. Reengineered processes
12. Data inventories and required data transformations
13. Reengineered processes

Data Architecture Engineering

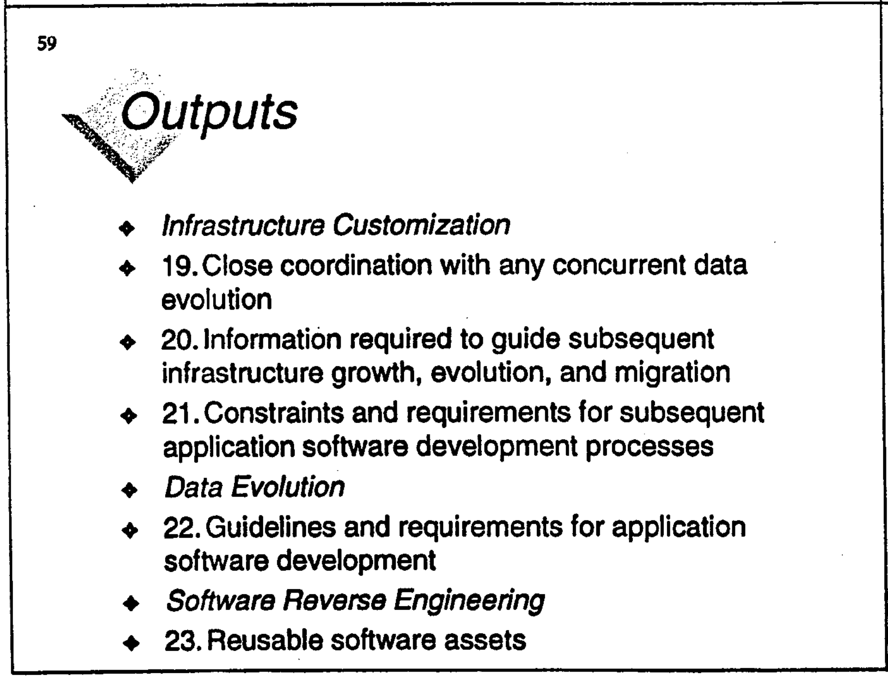
14. Data architecture-based data assets
15. Strategic guidance for data evolution
16. Data-based organizational infrastructure requirements

Infrastructure Development

17. Boundaries and/or standards

Software Architecture Development

18. Software architecture



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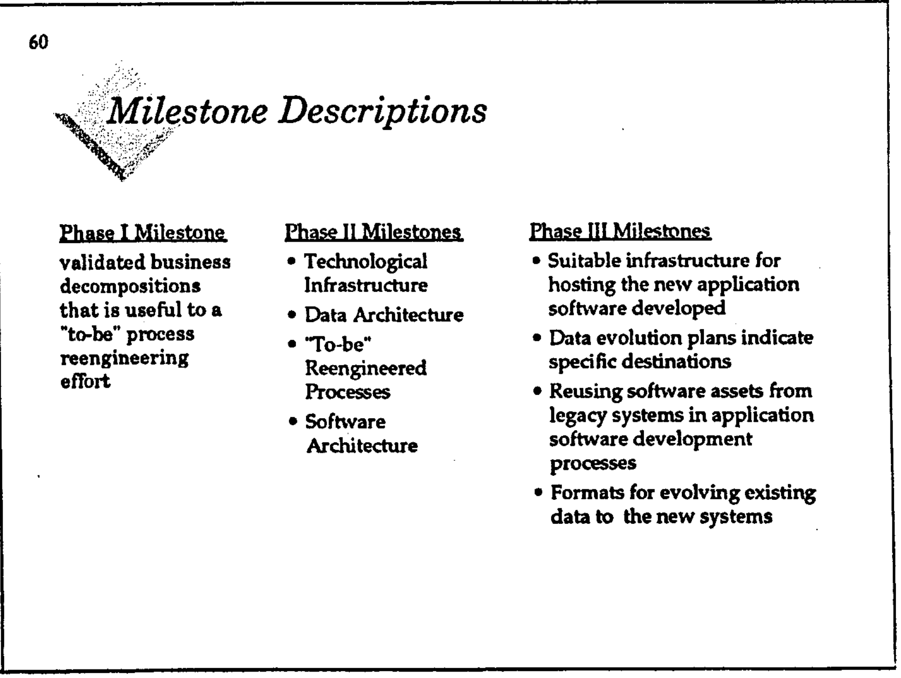
Outputs

- ◆ *Infrastructure Customization*
- ◆ 19. Close coordination with any concurrent data evolution
- ◆ 20. Information required to guide subsequent infrastructure growth, evolution, and migration
- ◆ 21. Constraints and requirements for subsequent application software development processes
- ◆ *Data Evolution*
- ◆ 22. Guidelines and requirements for application software development
- ◆ *Software Reverse Engineering*
- ◆ 23. Reusable software assets



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Milestone Descriptions

Phase I Milestone

validated business decompositions that is useful to a "to-be" process reengineering effort

Phase II Milestones

- Technological Infrastructure
- Data Architecture
- "To-be" Reengineered Processes
- Software Architecture

Phase III Milestones

- Suitable infrastructure for hosting the new application software developed
- Data evolution plans indicate specific destinations
- Reusing software assets from legacy systems in application software development processes
- Formats for evolving existing data to the new systems

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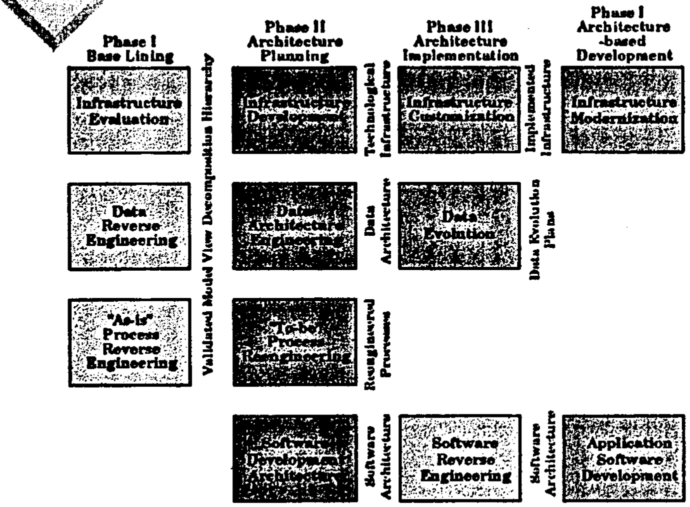
Milestones



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Q: Why Model?

- ❖ Models are used to help understand complex system behavior.
- ❖ Computer-based models are also an excellent means for storing and formalizing organizational information.
- ❖ Finally, models permit evaluation of various scenarios or other outcomes produced by the model.

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Answers a set of specific questions

- ❖ What are the primary data objects to be processed by the system?
- ❖ What is the composition of each data object and what attributes describe the object?
- ❖ Where do objects currently reside?
- ❖ What are the relationships between each object and other objects?
- ❖ What is the relationship between the objects and the processes which transform them?

[PRES, 1992, p. 220]

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Also ...

- ❖ Modeling is also used to filter out extraneous detail
- ❖ Model information can be considered basic or indispensable to understanding the system

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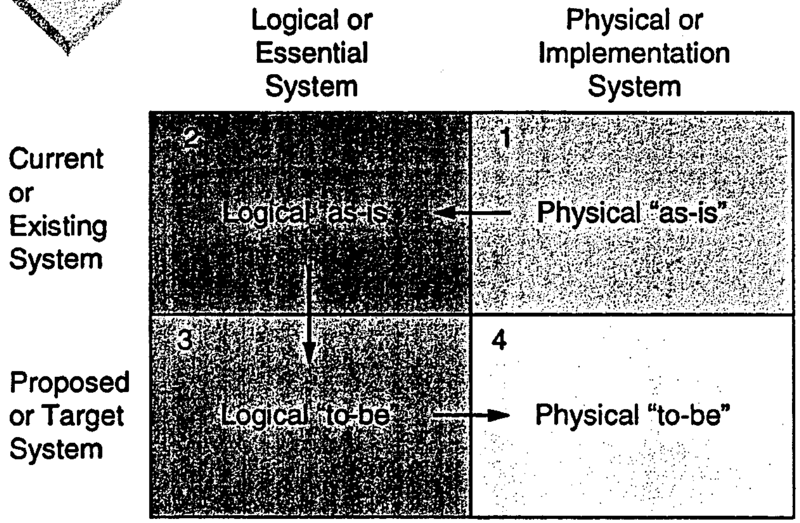
Modeling Types



Logical or Essential System

Physical or Implementation System

Current or Existing System

Proposed or Target System

2 Logical "as-is"

1 Physical "as-is"

3 Logical "to-be"

4 Physical "to-be"

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Why specify requirements in an implementation independent format?

Implementation independent models:

1. remove biases resulting from the current application or individuals - overcomes "we've always done it that way" syndrome - encourages creativity
2. reduce the risk of missing functional requirements because we are preoccupied with technical details - errors can be costly - separation of what from how permits better analysis for completeness, accuracy and consistency
3. allow us to communication with end-users in a non-technical language - avoids loosing communication through use of technical jargon

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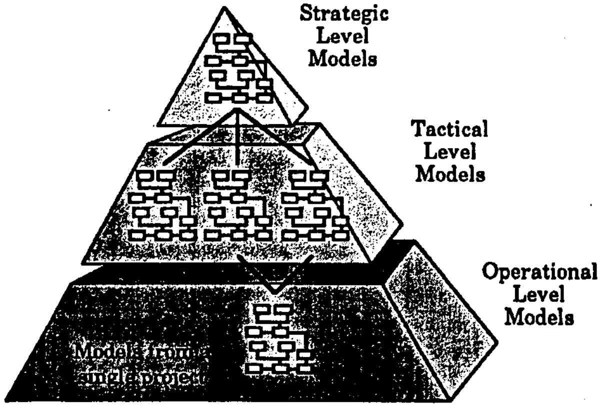
Information Modeling



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SOFTWARE REENGINEERING ASSESSMENT HANDBOOK (JLC-HDBK-SRAH)

Report to the
2nd SPC Reengineering Workshop

December 4-5, 1995

Robert E. Johnson, Jr.
Joint Logistics Commanders/
Computer Resources
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Va Beach, Va.
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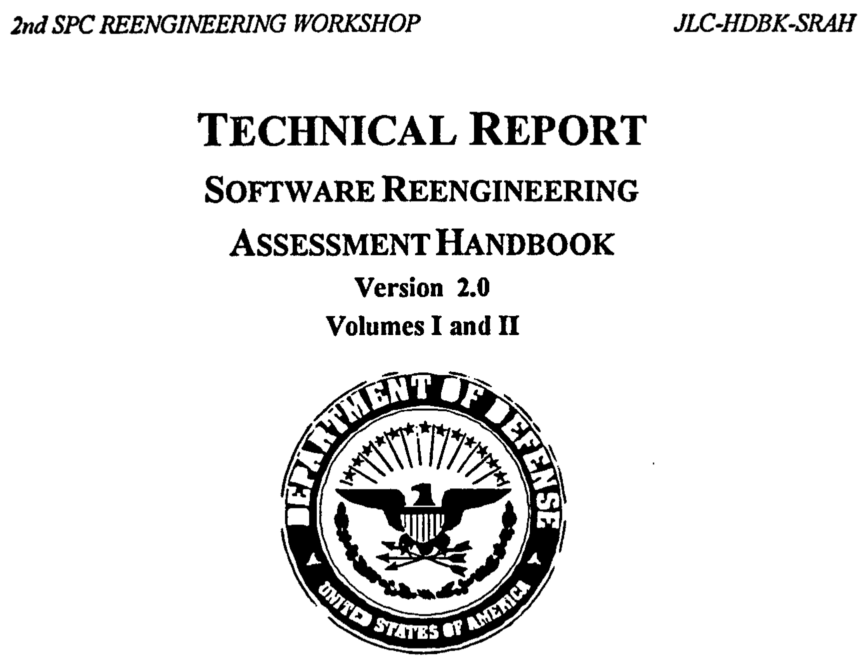
2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

INTRODUCTION

- TO INTRODUCE JLC-HDBK-SRAH, VERSION 2.0, MARCH 1995
  - A QUICK METHOD TO DETERMINE IF REENGINEERING IS NEEDED AND COST EFFECTIVE
- THREE SEQUENTIAL PROCESSES:
  - TECHNICAL ASSESSMENT: EVALUATE SOFTWARE CANDIDATES AND SELECT REENGINEERING STRATEGIES
  - ECONOMIC ASSESSMENT: CALCULATE ECONOMIC INDICATORS FOR EACH STRATEGY OF EACH CANDIDATE
  - MANAGEMENT DECISION: EVALUATE, SELECT, AND PRIORITIZE CANDIDATES AND THEIR STRATEGIES



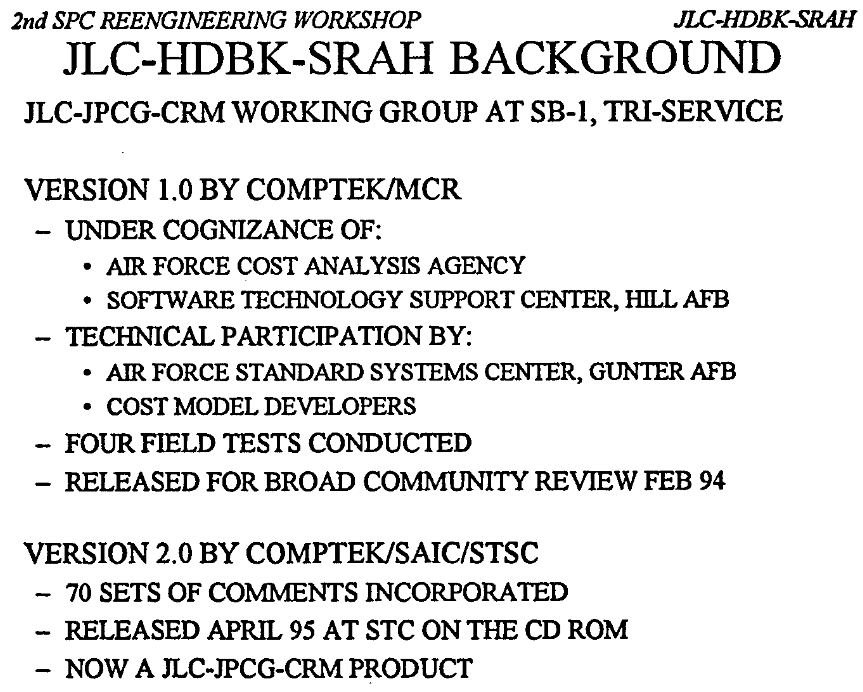
2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

TECHNICAL REPORT

SOFTWARE REENGINEERING ASSESSMENT HANDBOOK

Version 2.0

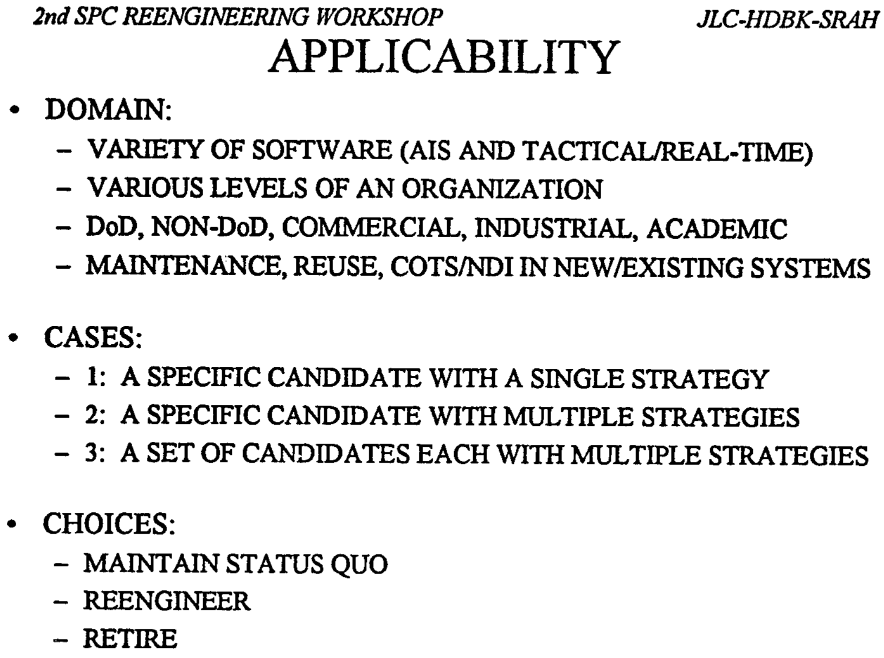
Volumes I and II



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

JLC-HDBK-SRAH BACKGROUND

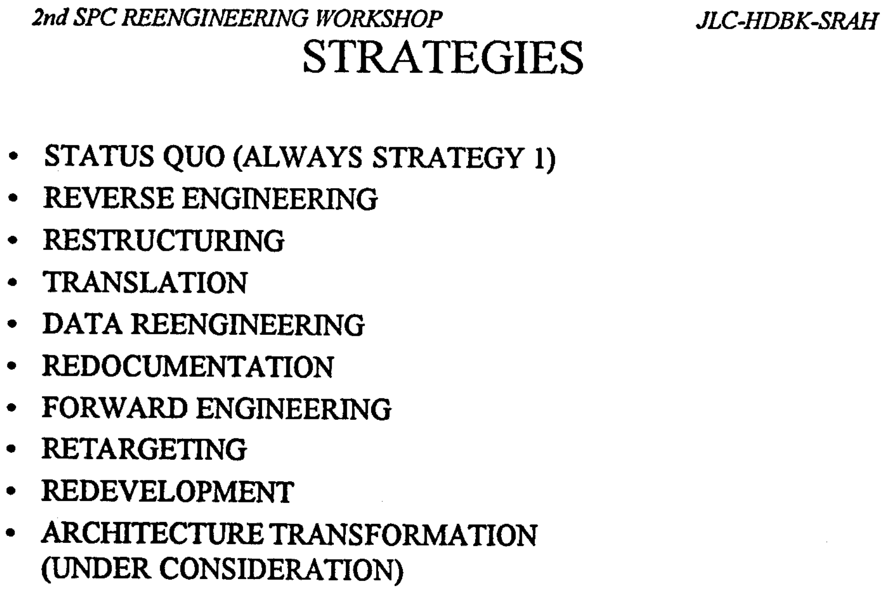
- JLC-JPCG-CRM WORKING GROUP AT SB-1, TRI-SERVICE
- VERSION 1.0 BY COMPTEK/MCR
  - UNDER COGNIZANCE OF:
    - AIR FORCE COST ANALYSIS AGENCY
    - SOFTWARE TECHNOLOGY SUPPORT CENTER, HILL AFB
  - TECHNICAL PARTICIPATION BY:
    - AIR FORCE STANDARD SYSTEMS CENTER, GUNTER AFB
    - COST MODEL DEVELOPERS
  - FOUR FIELD TESTS CONDUCTED
  - RELEASED FOR BROAD COMMUNITY REVIEW FEB 94
- VERSION 2.0 BY COMPTEK/SAIC/STSC
  - 70 SETS OF COMMENTS INCORPORATED
  - RELEASED APRIL 95 AT STC ON THE CD ROM
  - NOW A JLC-JPCG-CRM PRODUCT



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

APPLICABILITY

- DOMAIN:
  - VARIETY OF SOFTWARE (AIS AND TACTICAL/REAL-TIME)
  - VARIOUS LEVELS OF AN ORGANIZATION
  - DoD, NON-DoD, COMMERCIAL, INDUSTRIAL, ACADEMIC
  - MAINTENANCE, REUSE, COTS/NDI IN NEW/EXISTING SYSTEMS
- CASES:
  - 1: A SPECIFIC CANDIDATE WITH A SINGLE STRATEGY
  - 2: A SPECIFIC CANDIDATE WITH MULTIPLE STRATEGIES
  - 3: A SET OF CANDIDATES EACH WITH MULTIPLE STRATEGIES
- CHOICES:
  - MAINTAIN STATUS QUO
  - REENGINEER
  - RETIRE



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

STRATEGIES

- STATUS QUO (ALWAYS STRATEGY 1)
- REVERSE ENGINEERING
- RESTRUCTURING
- TRANSLATION
- DATA REENGINEERING
- REDOCUMENTATION
- FORWARD ENGINEERING
- RETARGETING
- REDEVELOPMENT
- ARCHITECTURE TRANSFORMATION (UNDER CONSIDERATION)

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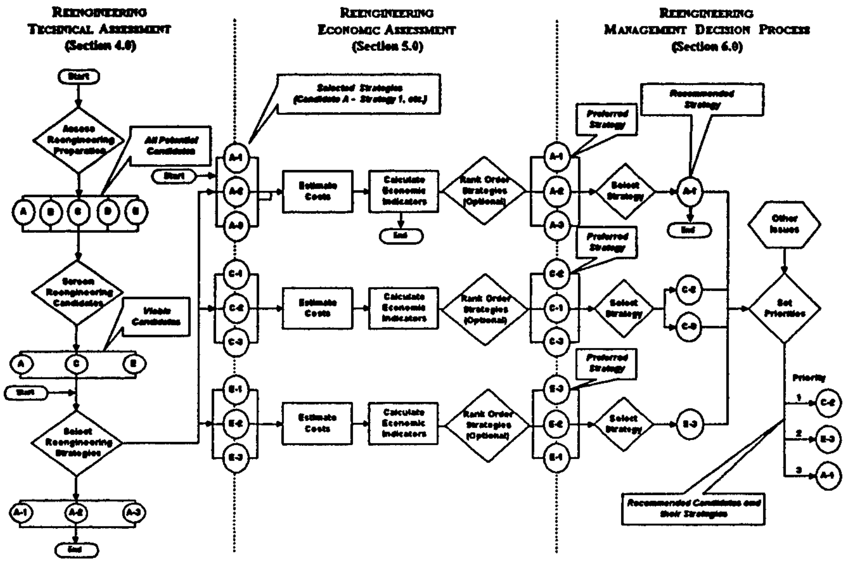
OVERALL PROCESS


Reengineering Technical Assessment (Section 4.0)
Reengineering Economic Assessment (Section 5.0)
Reengineering Management Decision Process (Section 6.0)
Start
Assess Reengineering Preparation
All Potential Candidates
A
B
C
D
E
Screen Reengineering Candidates
Viable Candidates
A
C
E
Start
Select Reengineering Strategies
A-1
A-2
A-3
End
Selected Strategies (Candidate A - Strategy 1, etc.)
Start
A-1
A-2
A-3
C-1
C-2
C-3
E-1
E-2
E-3
Estimate Costs
Calculate Economic Indicators
End
Rank Order Strategies (Optional)
Preferred Strategy
A-1
A-2
A-3
C-2
C-1
C-3
E-3
E-2
E-1
Select Strategy
Recommended Strategy
A-1
End
C-2
C-3
E-3
Other Issues
Set Priorities
Priority
1
C-2
2
E-3
3
A-1
Recommended Candidates and their Strategies

Note: A-1 indicates a candidate-strategy pair wherein 1 indicates Status Que

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TECHNICAL ASSESSMENT PROCESS (STRATEGY SELECTION)

- Purpose: To match legacy software components with reengineering strategies.
- Gives a rough idea of where reengineering can help maintenance activities for those organizations unaware of reengineering principles.
- Based on:
  - JLS's Santa Barbara - I Reengineering Workshop (Sept. 1992)
  - USAF organization interviews
  - Fiels tests of SRAH version 1.0
    - Gunter AFB, AL
    - Wright-Patterson AFB, OH
    - Lawrence Livermore Labs, CA
    - Hill AFB, UT
  - Initial reengineering survey results
  - Other reengineering projects data

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STRATEGY SELECTION (cont.)

- Reengineering Projects Data Repository
  - SRAH validation, modification, and enhancement
  - Will help with version 3.0 issues of
    - "Weighting" of questions
    - Software size issues
  - Pre and Post Surveys with Instruction Set
- 6 Reengineering Strategies
  - Redocument
  - Reverse Engineer
  - Translate Source Code
  - Data Reengineer
  - Restructure
  - Retarget
- 2 Classical Maintenance Strategies
  - Redevelopment
  - Status Quo

2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

STRATEGY SELECTION (cont.)

- Step 1: Assess Preparedness (Question Set)
- Step 2: Identify Software Candidates
  - Consider factors of age, complexity, language, reliability, HW/SW coupling, platform changes, etc.
- Step 3: Reduce List of Software Candidates
  - Suggest remove from list if:
    - Remaining life < 3 years
    - Not important enough (Importance question set)
    - Age < 5 years
    - Software directly supports ongoing BPR efforts
- Step 4: Complete Strategy Selection Question Sets
  - Redocument
  - Restructure
  - Translate Source Code
  - Data Reengineer
  - Retarget

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STRATEGY SELECTION (cont.)

- Step 5: Consider Other Maintenance Strategies
  - Reverse Engineer if:
    - Multiple reengineering strategies are indicated
    - Highly complex control flow
    - Reuse is a key objective
  - Redevelopment if:
    - 3 or more reengineering strategies indicated
    - Remaining life > 5 years
  - Status Quo if:
    - No reengineering strategies are indivcated
- Maintenance Environment Considerations (Question Set)
- Misc. Other Issues
  - Impotrance of Pilot Project
  - Impact Analysis
  - Pitfalls of Source Code Translation and Restructuring
  - Software Analysis Tools

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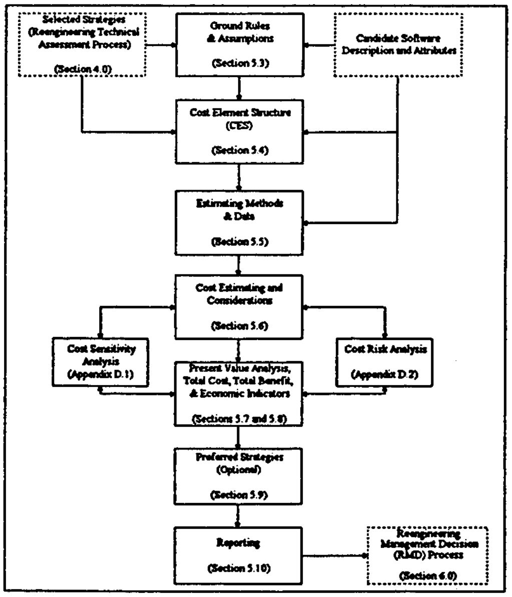
ECONOMIC ASSESSMENT PROCESS



Selected Strategies (Reengineering Technical Assessment Process) (Section 4.0)

Ground Rules & Assumptions (Section 5.3)

Candidate Software Description and Attributes

Cost Element Structure (CES) (Section 5.4)

Estimating Methods & Data (Section 5.5)

Cost Estimating and Considerations (Section 5.6)

Cost Sensitivity Analysis (Appendix D.1)

Cost Risk Analysis (Appendix D.2)

Present Value Analysis, Total Cost, Total Benefit, & Economic Indicators (Sections 5.7 and 5.8)

Preferred Strategies (Optional) (Section 5.9)

Reporting (Section 5.10)

Reengineering Management Decision (RMD) Process (Section 6.0)

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ECONOMIC TERMINOLOGY

- BENEFIT (QUANTIFIABLE AND NON-QUANTIFIABLE)
- BENEFIT INVESTMENT RATIO (BIR): 2ND BEST INDICATOR
- BREAK-EVEN POINT (BP)
- COST SAVINGS AND COST AVOIDANCE
- CONSTANT DOLLARS
- CURRENT DOLLARS
- DISCOUNTED DOLLARS
- INVESTMENT COST AND O&S COST
- NET VALUE (NV)
- PRESENT VALUE (PV)
- NET PRESENT VALUE (NPV): BEST INDICATOR
- RATE OF RETURN (ROR)
- SUNK COST
- UNIFORM ANNUAL COST

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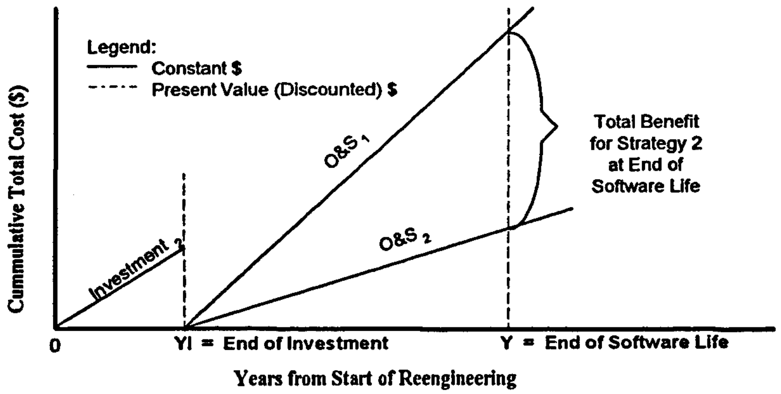
NET VALUE AND BIR



NET VALUE = BENEFIT - INVESTMENT

= O&S$_1$ - O&S$_N$ - INVESTMENT

> 0 : POSITIVE RETURN

< 0 : NEGATIVE RETURN

= 0 : BREAK-EVEN

BIR = BENEFIT / INVESTMENT

= (O&S$_1$ - O&S$_N$) / INVESTMENT

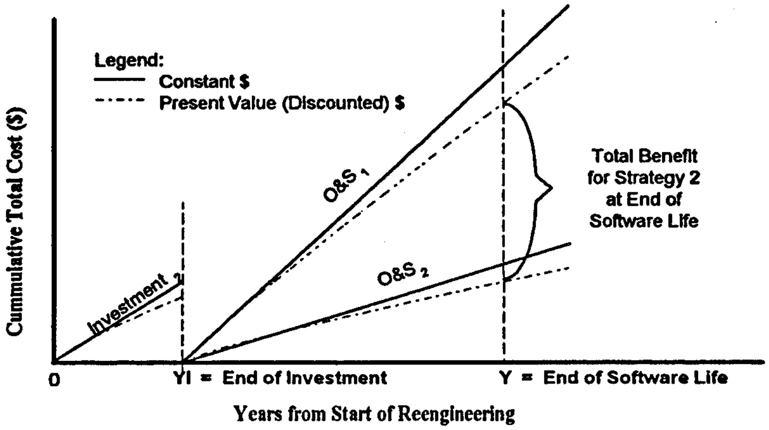
> 1 : POSITIVE RETURN

< 1 : NEGATIVE RETURN

= 1 : BREAK-EVEN

2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

NET PRESENT VALUE AND BIR



NET PRESENT VALUE = PV (BENEFIT) - PV (INVESTMENT)

= PV (O&S$_1$) - PV (O&S$_N$) - PV (INVESTMENT)

BENEFIT INVESTMENT RATIO = PV (BENEFIT) / PV (INVESTMENT)

= (PV (O&S$_1$) - PV (O&S$_N$)) / PV (INVESTMENT)

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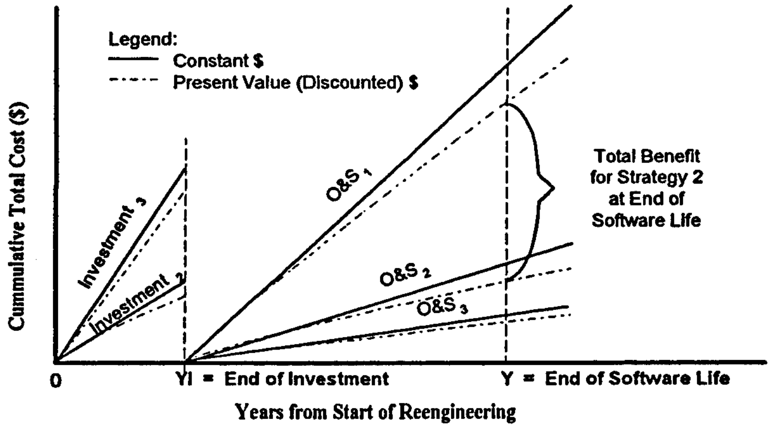
STRATEGY SELECTION



WHICH STRATEGY IS BEST: 1, 2 OR 3 ?

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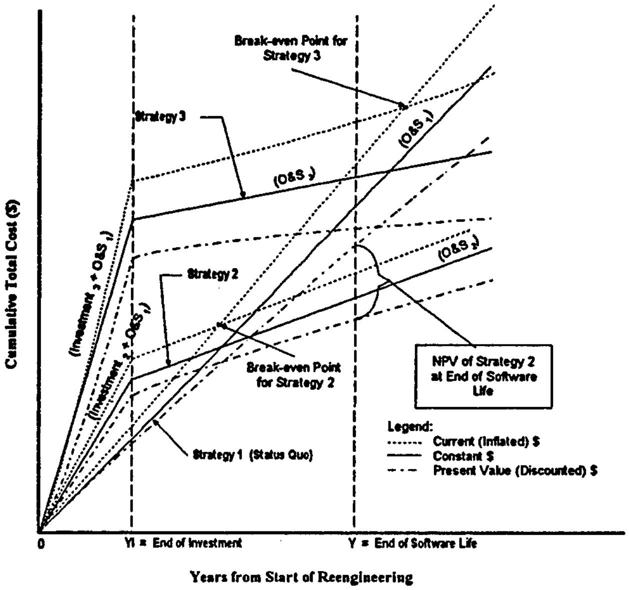
TOTAL COST AND BP



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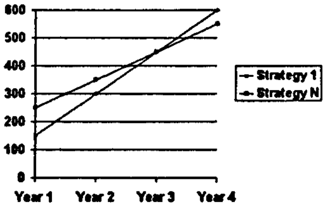
SIMPLIFIED EXAMPLE
(no discounting or inflation)

Cost Type	Year	Cost of Status Quo	Cost of Strategy N	Benefit
Investment	1	NA	100	NA
O&S	1	150	150	0
O&S	2	150	100	50
O&S	3	150	100	50
O&S	4	150	100	50
Total		600	550	150

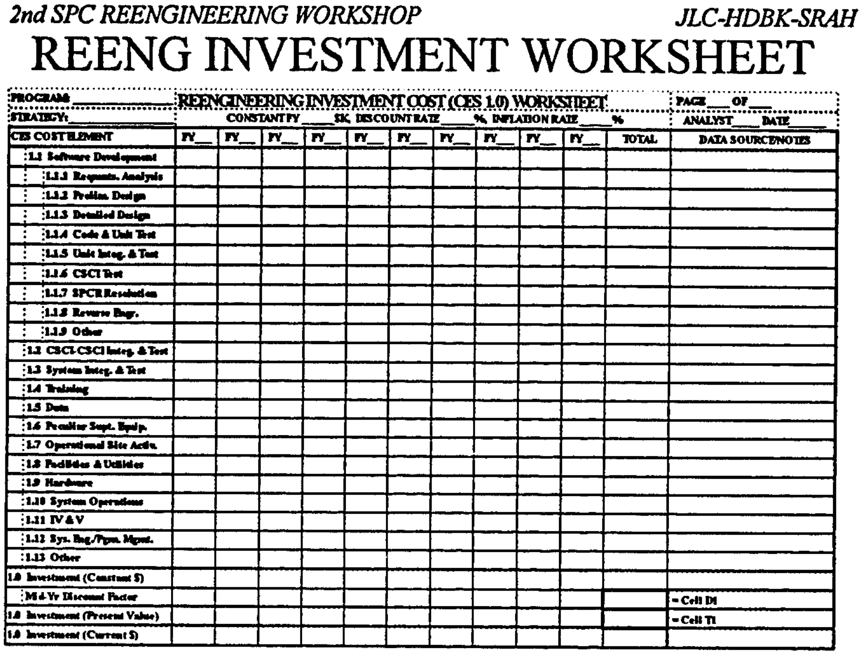


NV = 150 - 100 = 50 or 600 - 550 = 50, BIR = 150 / 100 = 1.5

BP = Year 3 when cumulative benefit = investment = 100

ROR = i = 0.234 or 23.4 % when:

$$\frac{100}{(1+i)^1} = \frac{0}{(1+i)^1} + \frac{50}{(1+i)^2} + \frac{50}{(1+i)^3} + \frac{50}{(1+i)^4}$$



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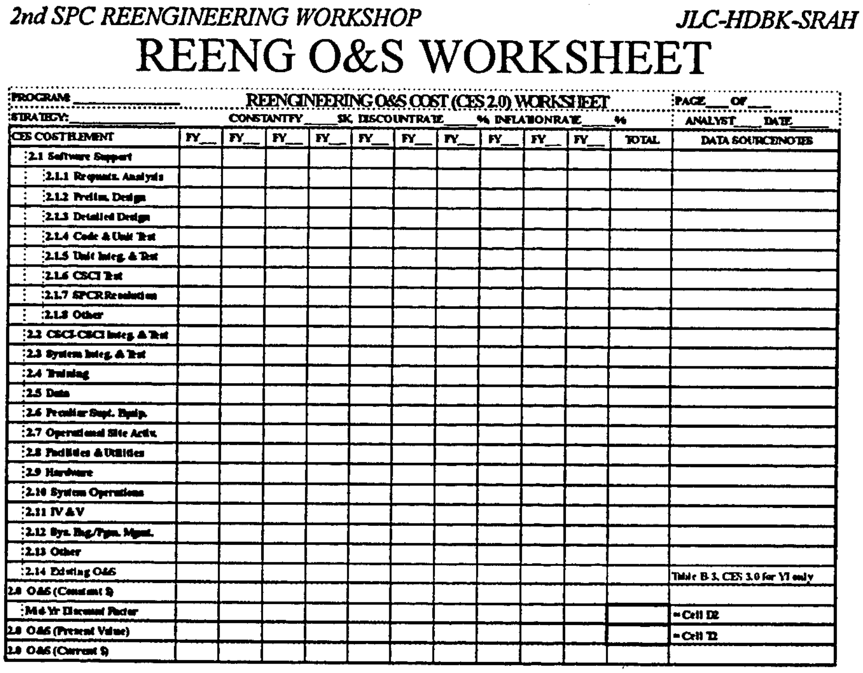
REENG INVESTMENT WORKSHEET

PROGRAM: ______________ REENGINEERING INVESTMENT COST (CES 1.0) WORKSHEET PAGE ___ OF ___

STRATEGY: ______________ CONSTANT FY _____ $K, DISCOUNT RATE _____ %, INFLATION RATE _____ % ANALYST ____ DATE ______

CES COST ELEMENT	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	TOTAL	DATA SOURCE/NOTES
1.1 Software Development												
1.1.1 Requmts. Analysis												
1.1.2 Prelim. Design												
1.1.3 Detailed Design												
1.1.4 Code & Unit Test												
1.1.5 Unit Integ. & Test												
1.1.6 CSCI Test												
1.1.7 SPCR Resolution												
1.1.8 Reverse Engr.												
1.1.9 Other												
1.2 CSCI-CSCI Integ. & Test												
1.3 System Integ. & Test												
1.4 Training												
1.5 Data												
1.6 Peculiar Supt. Equip.												
1.7 Operational Site Activ.												
1.8 Facilities & Utilities												
1.9 Hardware												
1.10 System Operations												
1.11 IV & V												
1.12 Sys. Eng./Pgm. Mgmt.												
1.13 Other												
1.0 Investment (Constant $)												
Mid-Yr Discount Factor												= Cell D1
1.0 Investment (Present Value)												= Cell T1
1.0 Investment (Current $)												



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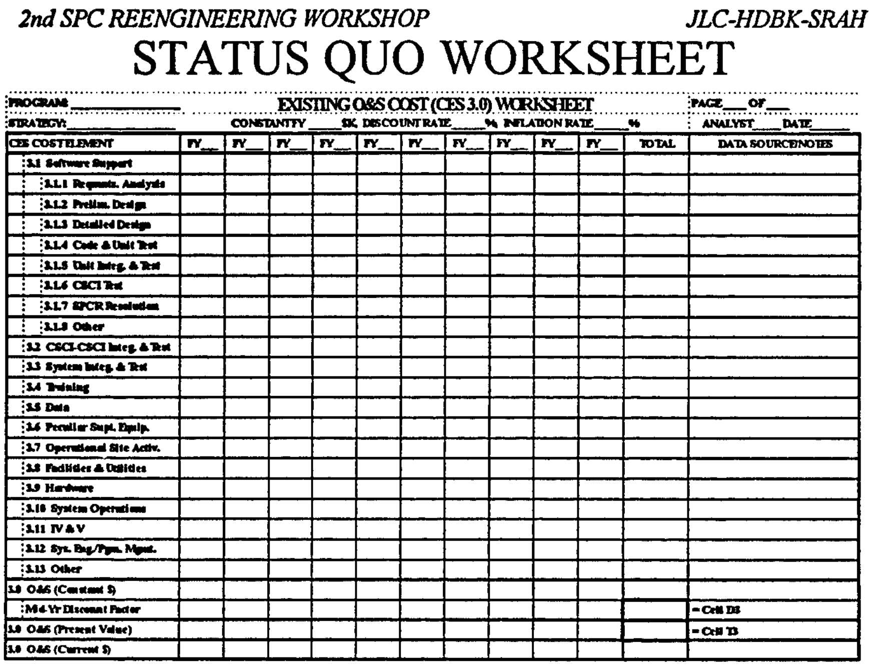
REENG O&S WORKSHEET

PROGRAM: ______________ REENGINEERING O&S COST (CES 2.0) WORKSHEET PAGE ___ OF ___

STRATEGY: ______________ CONSTANT FY _____ $K, DISCOUNT RATE _____ % INFLATION RATE _____ % ANALYST ____ DATE ______

CES COST ELEMENT	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	TOTAL	DATA SOURCE/NOTES
2.1 Software Support												
2.1.1 Requmts. Analysis												
2.1.2 Prelim. Design												
2.1.3 Detailed Design												
2.1.4 Code & Unit Test												
2.1.5 Unit Integ. & Test												
2.1.6 CSCI Test												
2.1.7 SPCR Resolution												
2.1.8 Other												
2.2 CSCI-CSCI Integ. & Test												
2.3 System Integ. & Test												
2.4 Training												
2.5 Data												
2.6 Peculiar Supt. Equip.												
2.7 Operational Site Activ.												
2.8 Facilities & Utilities												
2.9 Hardware												
2.10 System Operations												
2.11 IV & V												
2.12 Sys. Eng./Pgm. Mgmt.												
2.13 Other												
2.14 Existing O&S												Table B-3, CES 3.0 for Y1 only
2.0 O&S (Constant $)												
Mid-Yr Discount Factor												= Cell D2
2.0 O&S (Present Value)												= Cell T2
2.0 O&S (Current $)												



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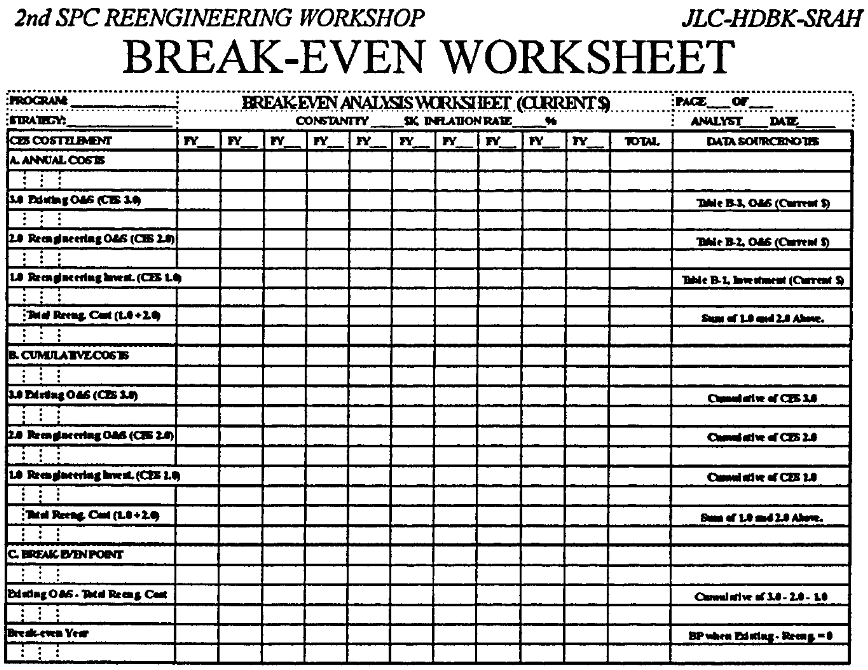
STATUS QUO WORKSHEET

PROGRAM: ______________ EXISTING O&S COST (CES 3.0) WORKSHEET PAGE___ OF___

STRATEGY: ______________ CONSTANT FY ____ $K, DISCOUNT RATE____% INFLATION RATE____% ANALYST____ DATE______

CES COSTELEMENT	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	TOTAL	DATA SOURCE/NOTES
3.1 Software Support												
3.1.1 Requmnts. Analysis												
3.1.2 Prelim. Design												
3.1.3 Detailed Design												
3.1.4 Code & Unit Test												
3.1.5 Unit Integ. & Test												
3.1.6 CSCI Test												
3.1.7 SPCR Resolution												
3.1.8 Other												
3.2 CSCI-CSCI Integ. & Test												
3.3 System Integ. & Test												
3.4 Training												
3.5 Data												
3.6 Peculiar Supt. Equip.												
3.7 Operational Site Activ.												
3.8 Facilities & Utilities												
3.9 Hardware												
3.10 System Operations												
3.11 IV & V												
3.12 Sys. Eng/Pgm. Mgmt.												
3.13 Other												
3.0 O&S (Constant $)												
Mid-Yr Discount Factor												= Cell D3
3.0 O&S (Present Value)												= Cell T3
3.0 O&S (Current $)												



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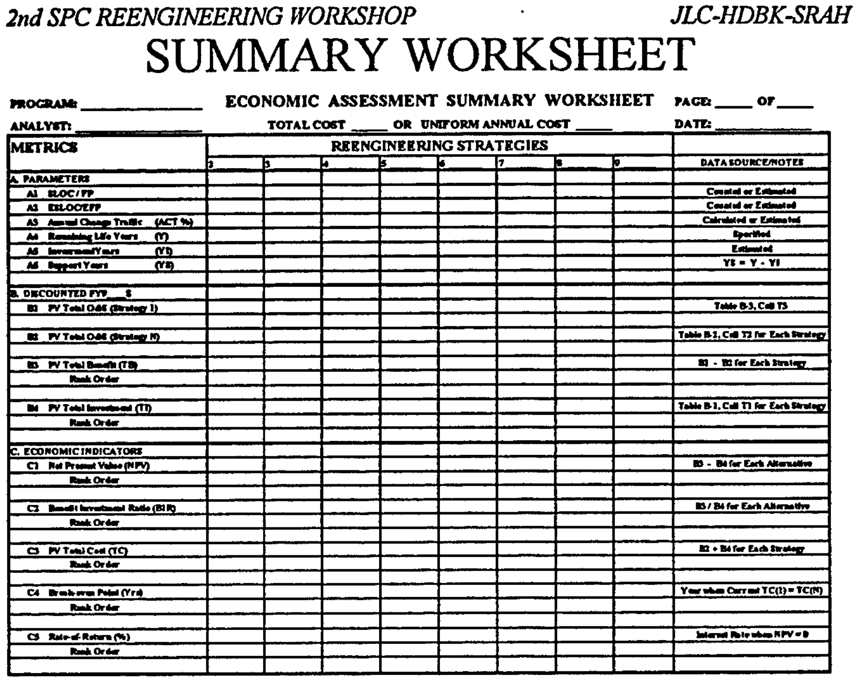
BREAK-EVEN WORKSHEET

PROGRAM: ______________ BREAK-EVEN ANALYSIS WORKSHEET (CURRENT $) PAGE___ OF___

STRATEGY: ______________ CONSTANT FY ____ $K, INFLATION RATE____% ANALYST____ DATE______

CES COSTELEMENT	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	FY__	TOTAL	DATA SOURCE/NOTES
A. ANNUAL COSTS												
: : :												
3.0 Existing O&S (CES 3.0)												Table B-3, O&S (Current $)
: : :												
2.0 Reengineering O&S (CES 2.0)												Table B-2, O&S (Current $)
: : :												
1.0 Reengineering Invest. (CES 1.0)												Table B-1, Investment (Current $)
: : :												
Total Reeng. Cost (1.0 + 2.0)												Sum of 1.0 and 2.0 Above.
: : :												
B. CUMULATIVE COSTS												
: : :												
3.0 Existing O&S (CES 3.0)												Cumulative of CES 3.0
: : :												
2.0 Reengineering O&S (CES 2.0)												Cumulative of CES 2.0
: : :												
1.0 Reengineering Invest. (CES 1.0)												Cumulative of CES 1.0
: : :												
Total Reeng. Cost (1.0 + 2.0)												Sum of 1.0 and 2.0 Above.
: : :												
C. BREAK-EVEN POINT												
: : :												
Existing O&S - Total Reeng. Cost												Cumulative of 3.0 - 2.0 - 1.0
: : :												
Break-even Year												BP when Existing - Reeng. = 0
: : :												



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SUMMARY WORKSHEET

PROGRAM: ______________ ECONOMIC ASSESSMENT SUMMARY WORKSHEET PAGE: ____ OF ____

ANALYST: ______________ TOTAL COST ____ OR UNIFORM ANNUAL COST ____ DATE: __________

METRICS	REENGINEERING STRATEGIES								
	2	3	4	5	6	7	8	9	DATA SOURCE/NOTES
A. PARAMETERS									
A1 SLOC/FP									Counted or Estimated
A2 ESLOC/EFP									Counted or Estimated
A3 Annual Change Traffic (ACT %)									Calculated or Estimated
A4 Remaining Life Years (Y)									Specified
A5 Investment Years (YI)									Estimated
A6 Support Years (YS)									YS = Y - YI
B. DISCOUNTED FY__ $									
B1 PV Total O&S (Strategy 1)									Table B-3, Cell T3
B2 PV Total O&S (Strategy N)									Table B-2, Cell T2 for Each Strategy
B3 PV Total Benefit (TB)									B1 - B2 for Each Strategy
Rank Order									
B4 PV Total Investment (TI)									Table B-1, Cell T1 for Each Strategy
Rank Order									
C. ECONOMIC INDICATORS									
C1 Net Present Value (NPV)									B3 - B4 for Each Alternative
Rank Order									
C2 Benefit Investment Ratio (BIR)									B3 / B4 for Each Alternative
Rank Order									
C3 PV Total Cost (TC)									B2 + B4 for Each Strategy
Rank Order									
C4 Break-even Point (Yrs)									Year when Current TC(1) = TC(N)
Rank Order									
C5 Rate-of-Return (%)									Internal Rate when NPV = 0
Rank Order									

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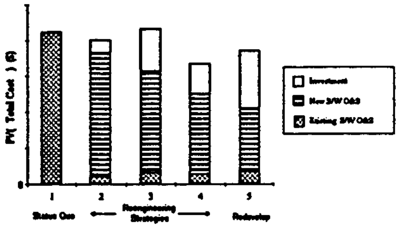
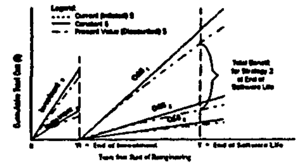
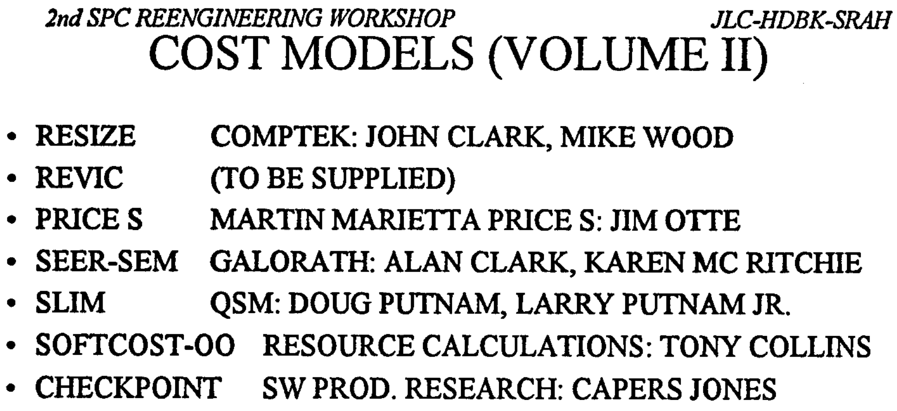
ECONOMIC REPORT





Section	Description
1.0	Overview
1.1	Background
1.2	Scope
1.3	Major Assumptions
1.4	Major Constraints
2.0	Alternatives
3.0	Summary
3.1	Cost Summary
3.2	Benefit Summary
3.3	Sensitivity Analysis Summary
3.4	Risk Analysis Summary
3.5	Summary of Recommendations
3.6	Program/Project Mgmt Charter
4.0	Analyses
4.1	Benefit Analysis
4.2	Sensitivity Analysis
4.3	Risk Analysis
4.4	Conclusion
4.5	Cost Data Sheets
4.6	Variable Explanation Sheets



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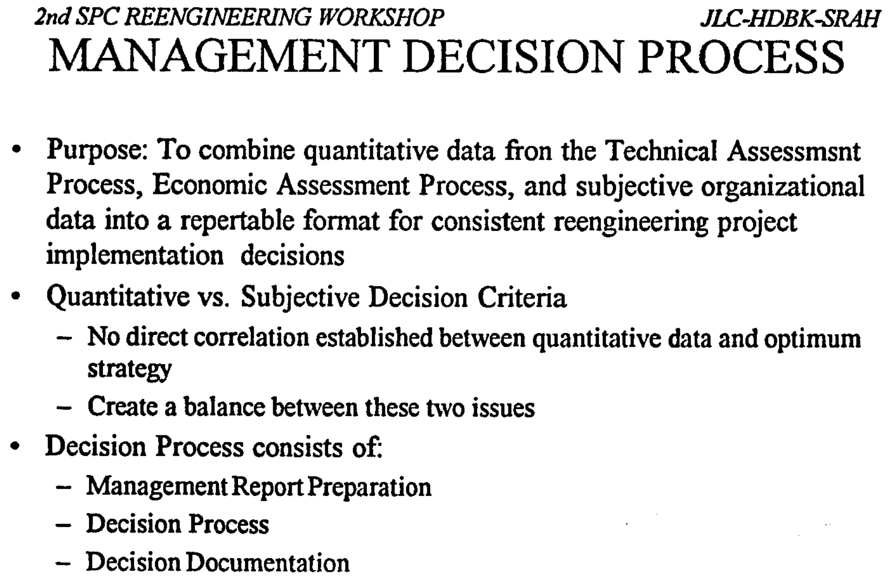
COST MODELS (VOLUME II)

• RESIZE	COMPTEK: JOHN CLARK, MIKE WOOD
• REVIC	(TO BE SUPPLIED)
• PRICE S	MARTIN MARIETTA PRICE S: JIM OTTE
• SEER-SEM	GALORATH: ALAN CLARK, KAREN MC RITCHIE
• SLIM	QSM: DOUG PUTNAM, LARRY PUTNAM JR.
• SOFTCOST-OO	RESOURCE CALCULATIONS: TONY COLLINS
• CHECKPOINT	SW PROD. RESEARCH: CAPERS JONES



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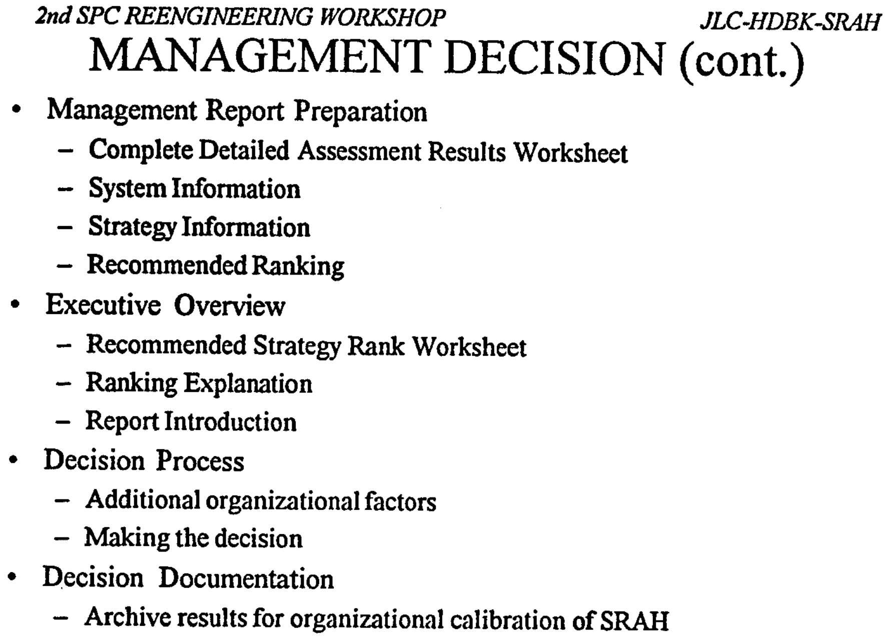
MANAGEMENT DECISION PROCESS

- Purpose: To combine quantitative data fron the Technical Assessmsnt Process, Economic Assessment Process, and subjective organizational data into a repertable format for consistent reengineering project implementation decisions
- Quantitative vs. Subjective Decision Criteria
  - No direct correlation established between quantitative data and optimum strategy
  - Create a balance between these two issues
- Decision Process consists of:
  - Management Report Preparation
  - Decision Process
  - Decision Documentation



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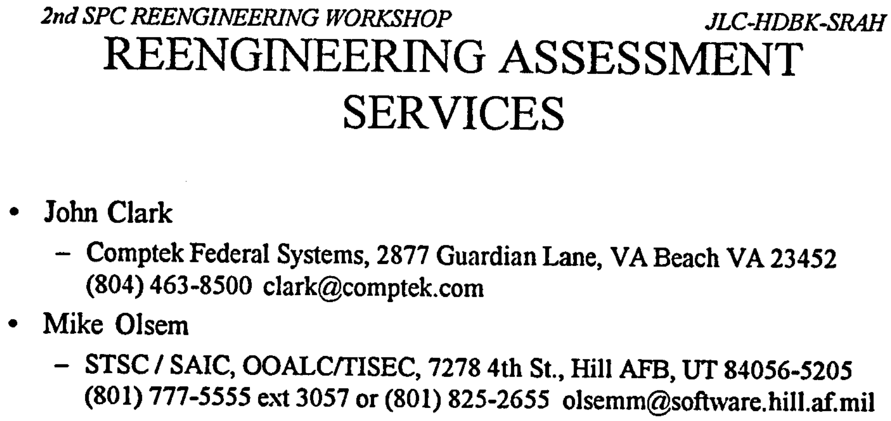
MANAGEMENT DECISION (cont.)

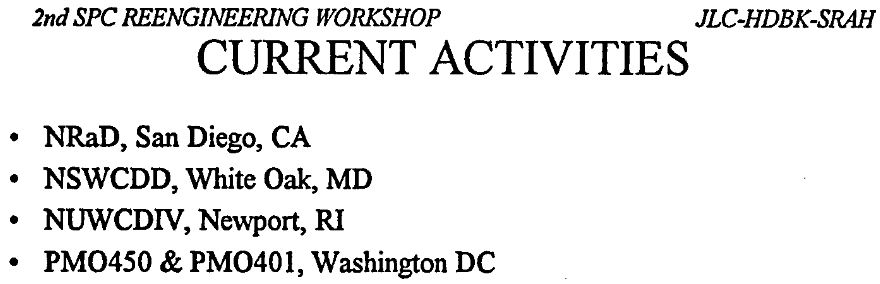
- Management Report Preparation
  - Complete Detailed Assessment Results Worksheet
  - System Information
  - Strategy Information
  - Recommended Ranking
- Executive Overview
  - Recommended Strategy Rank Worksheet
  - Ranking Explanation
  - Report Introduction
- Decision Process
  - Additional organizational factors
  - Making the decision
- Decision Documentation
  - Archive results for organizational calibration of SRAH



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

REENGINEERING ASSESSMENT SERVICES

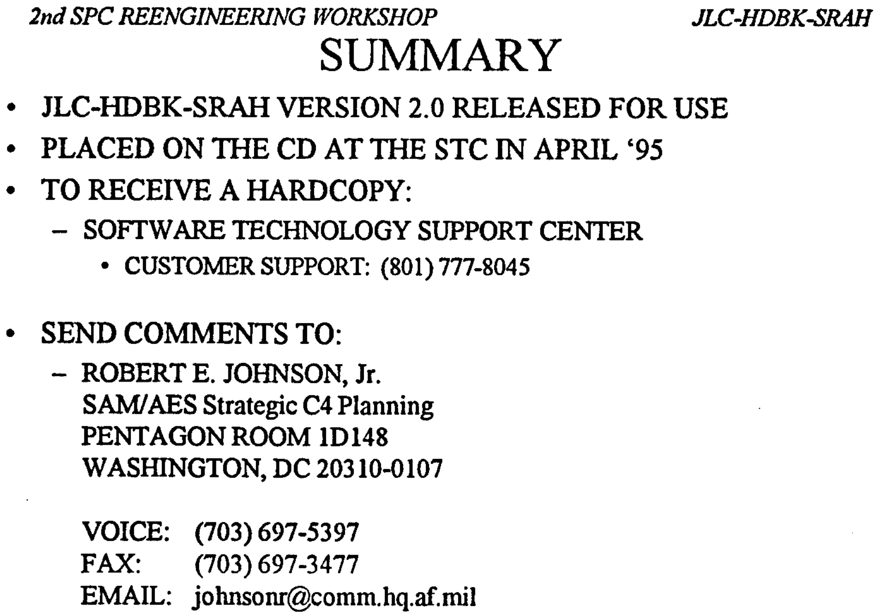
- John Clark
  - Comptek Federal Systems, 2877 Guardian Lane, VA Beach VA 23452
    (804) 463-8500 clark@comptek.com
- Mike Olsem
  - STSC / SAIC, OOALC/TISEC, 7278 4th St., Hill AFB, UT 84056-5205
    (801) 777-5555 ext 3057 or (801) 825-2655 olsemm@software.hill.af.mil



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

CURRENT ACTIVITIES

- NRaD, San Diego, CA
- NSWCDD, White Oak, MD
- NUWCDIV, Newport, RI
- PMO450 & PMO401, Washington DC



2nd SPC REENGINEERING WORKSHOP *JLC-HDBK-SRAH*

SUMMARY

- JLC-HDBK-SRAH VERSION 2.0 RELEASED FOR USE
- PLACED ON THE CD AT THE STC IN APRIL '95
- TO RECEIVE A HARDCOPY:
  - SOFTWARE TECHNOLOGY SUPPORT CENTER
    - CUSTOMER SUPPORT: (801) 777-8045
- SEND COMMENTS TO:
  - ROBERT E. JOHNSON, Jr.
    SAM/AES Strategic C4 Planning
    PENTAGON ROOM 1D148
    WASHINGTON, DC 20310-0107

    VOICE: (703) 697-5397
    FAX: (703) 697-3477
    EMAIL: johnsonr@comm.hq.af.mil

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Software Productivity Consortium
2nd SPC Reengineering Workshop
December 4, 1995

CLASSIFYING TOOLS FOR REENGINEERING: A STATE OF THE INDUSTRY

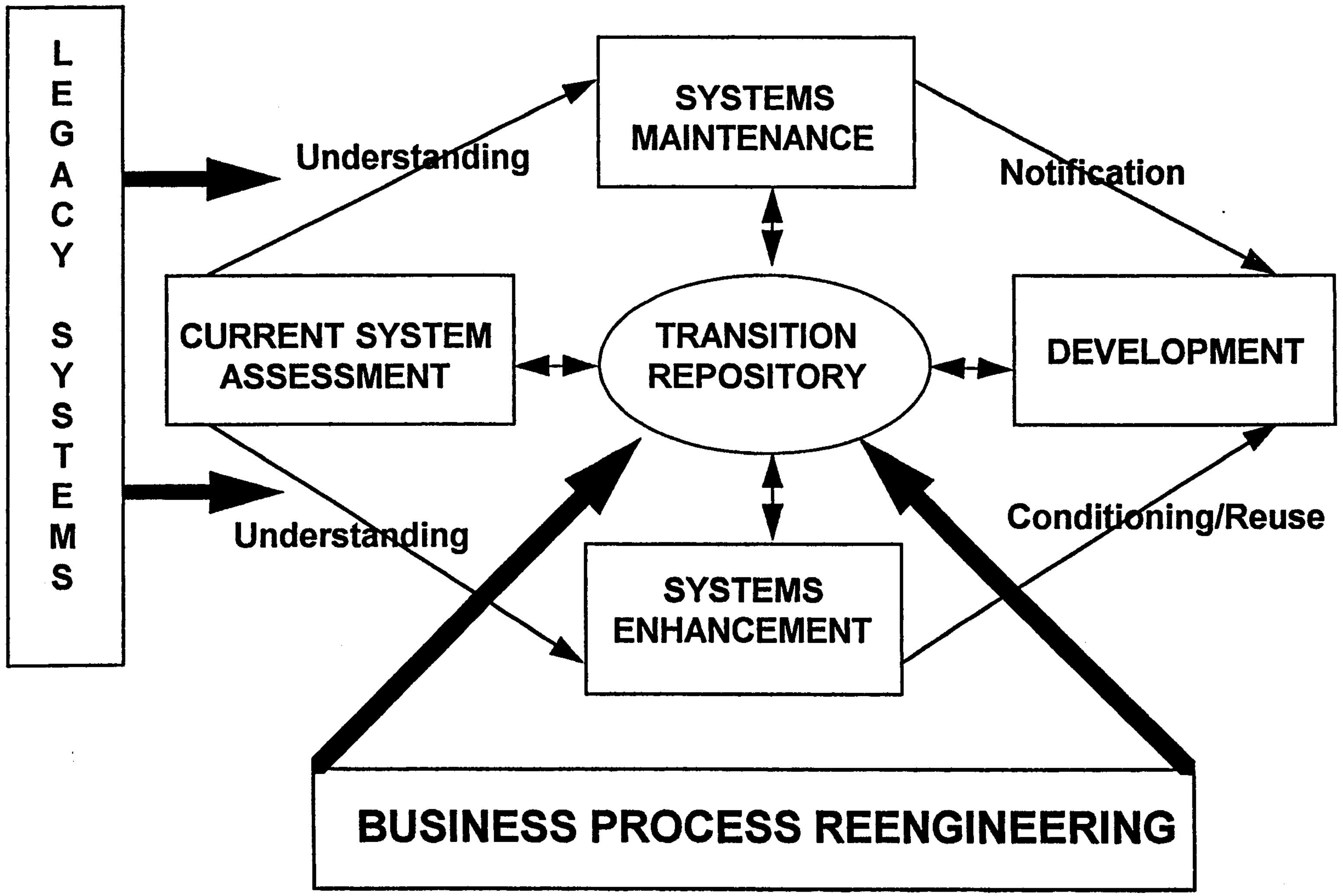
Presented By:
David Sharon
CASE Associates Inc.
14915 SE 82nd Drive
Clackamas, OR 97015
(503) 656-0986

WM. DAVID SHARON
PRESIDENT
CASE ASSOCIATES INC.

A Member of the Spectrum Institute

- Over 28 years of software industry experience
- The CASE Industry Advisor to Software Magazine
- Researcher and Publisher of the CASE Locator®, CASE Buyer's Guide®, and CASE Almanac®
- Contributing Editor to Application Development Trends
- Tool Box Column Editor for IEEE Software
- Author of a soon-to-be-published book Managing Systems in Transition and of CAI's Business/System Process Improvement Program Developer®
- Since 1991, a Judge for the ITAA Quality Award Program
- On Board of Directors of the Systems Development Forum
- Current Secretary of the IEEE Task Force on Professional Tools
- A Founder and Former Editor/Market Analyst of the CASE Outlook
- Former Director of Product Marketing, Nastec Corporation and Former Marketing Manager, CASE Division, Tektronix, Inc.
- BS from University of California, Berkeley, and MBA from Portland State University

THE RELATIONSHIP OF SYSTEMS MAINTENANCE, ENHANCEMENT, AND DEVELOPMENT



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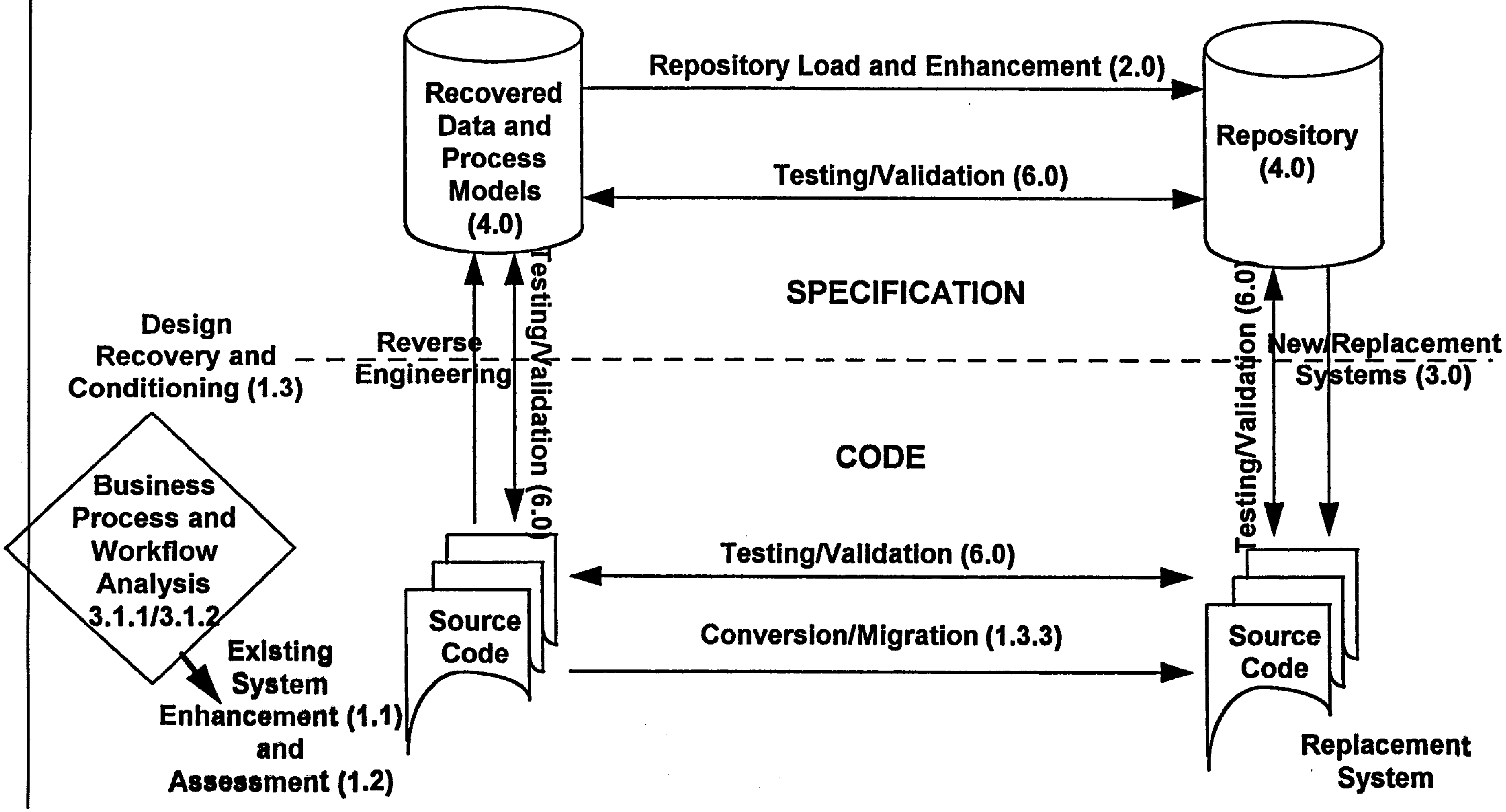
THE RELATIONSHIP BETWEEN APPLICATION DEVELOPMENT, MAINTENANCE, AND REENGINEERING


Recovered Data and Process Models (4.0)
Repository Load and Enhancement (2.0)
Repository (4.0)
Testing/Validation (6.0)
SPECIFICATION
Design Recovery and Conditioning (1.3)
Reverse Engineering
Testing/Validation (6.0)
Testing/Validation (6.0)
New/Replacement Systems (3.0)
CODE
Business Process and Workflow Analysis 3.1.1/3.1.2
Testing/Validation (6.0)
Source Code
Conversion/Migration (1.3.3)
Source Code
Existing System Enhancement (1.1) and Assessment (1.2)
Replacement System

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THE MAJOR CLASSES

1.0 EXISTING SYSTEMS
2.0 REPOSITORY LOAD/ENHANCEMENT
3.0 NEW/REPLACEMENT SYSTEMS
4.0 REPOSITORIES
5.0 INTEGRATED TOOL SET ENVIRONMENTS
6.0 TESTING/VALIDATION
7.0 SOFTWARE/PROJECT MANAGEMENT
8.0 DBMS/NETWORK/FILE MANAGEMENT
0.0 MISCELLANEOUS

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

1.0 Existing systems
- 1.1 Enhancement
  - 1.1.1 Smart editors/browsers
  - 1.1.2 Maintenance environment
- 1.2 Assessment
  - 1.2.1 Measurement
  - 1.2.2 Inventory/analysis
  - 1.2.3 Redocumentation
- 1.3 Conditioning
  - 1.3.1 Data rationalization
  - 1.3.2 Process rationalization
  - 1.3.3 Conversion/migration
  - 1.3.4 Code (process) restructuring

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

2.0 Repository load/enhancement and reconciliation
- 2.1 Data
- 2.2 Process

3.0 New/replacement systems
- 3.1 Planning
  - 3.1.1 Modeling/BPA/workflow analysis
  - 3.1.2 Strategic planning
- 3.2 Analysis/design
  - 3.2.1 SA/SD
  - 3.2.2 OOA/OOD
  - 3.2.3 Other models

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

3.3 Construction
- 3.3.1 Code generators (non-OO)
- 3.3.2 OO language tools
- 3.3.3 Visual programming tools
- 3.3.4 4GLs
- 3.3.5 Compilers

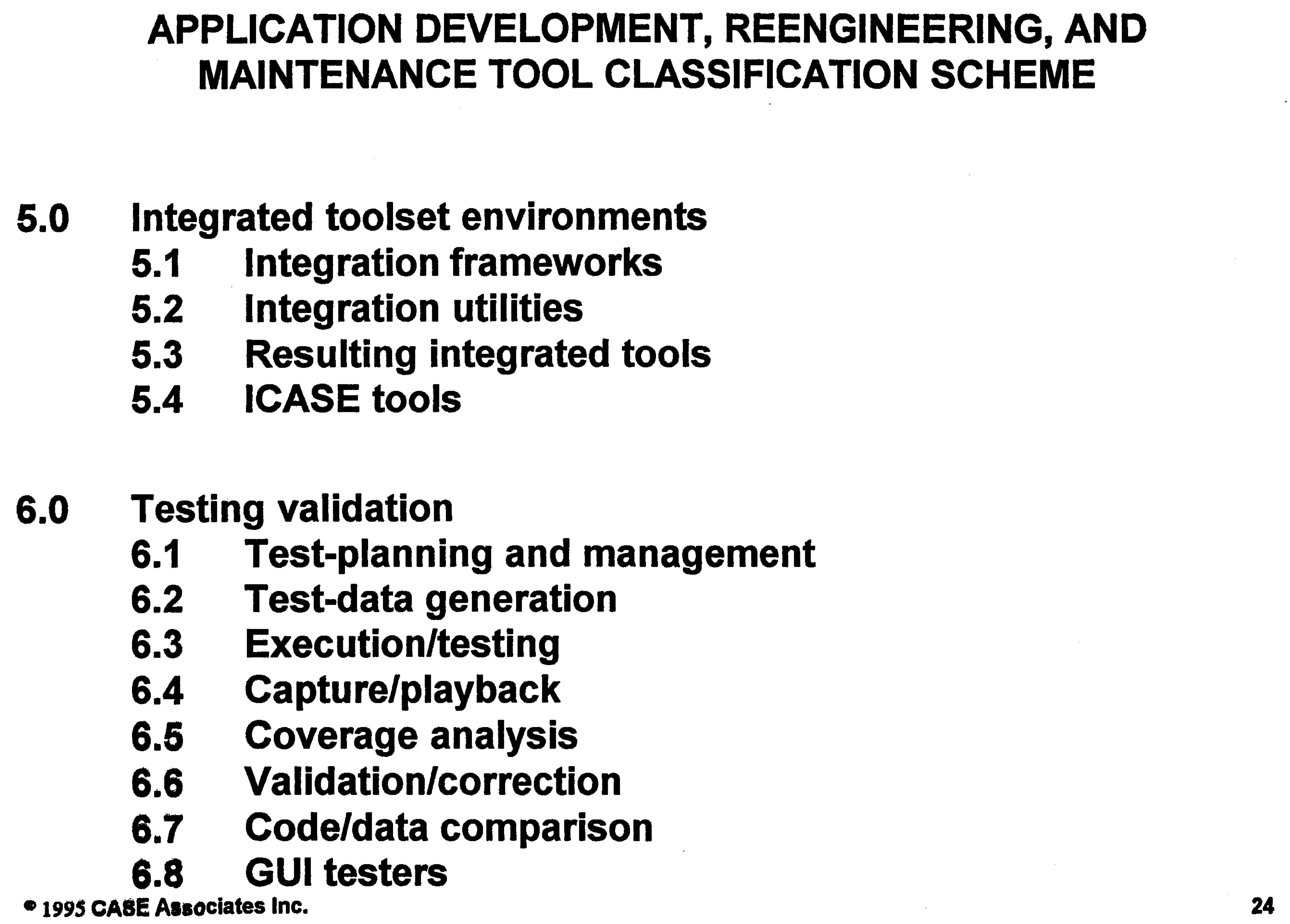
3.4 GUI builder

3.5 Prototyping/simulation

3.9 MetaCASE

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

4.0 Repositories
- 4.1 Repositories/data dictionaries
- 4.2 Repository/data-dictionary manager
    - 4.2.1 Object management systems
    - 4.2.2 Reuse management systems
- 4.3 Data warehouse



APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

5.0 Integrated toolset environments
- 5.1 Integration frameworks
- 5.2 Integration utilities
- 5.3 Resulting integrated tools
- 5.4 ICASE tools

6.0 Testing validation
- 6.1 Test-planning and management
- 6.2 Test-data generation
- 6.3 Execution/testing
- 6.4 Capture/playback
- 6.5 Coverage analysis
- 6.6 Validation/correction
- 6.7 Code/data comparison
- 6.8 GUI testers

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

7.0 Software/project management

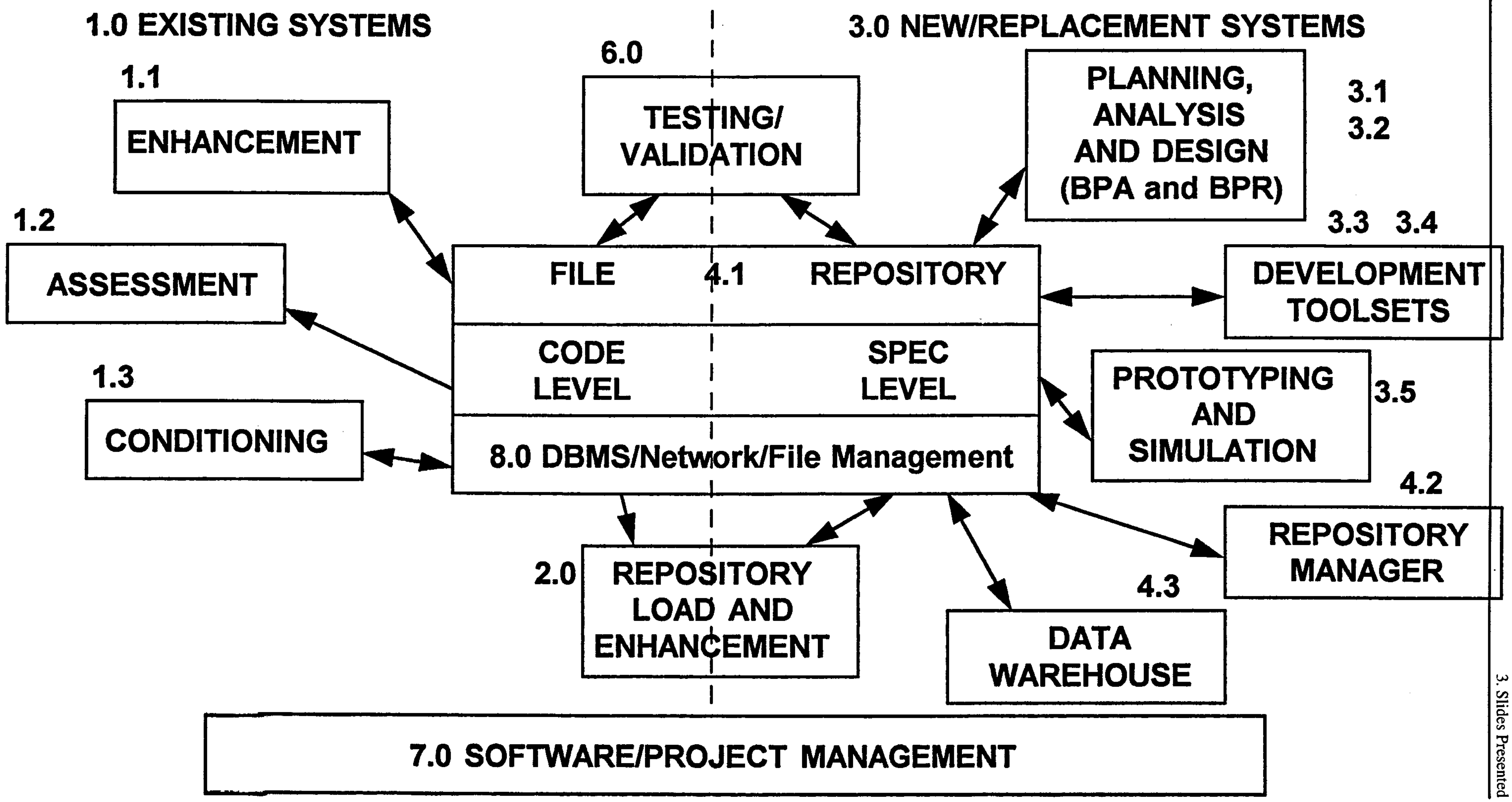
- 7.1 Process workbenches/managers
- 7.2 Process management methodology
- 7.3 Project management
- 7.4 Estimation/projection
- 7.5 Job accounting/chargeback
- 7.6 Performance management
- 7.7 Problem tracking
- 7.8 Configuration management
- 7.9 Document management
- 7.10 Requirements management
- 7.11 Operations management
- 7.12 Training
- 7.13 Acquisition/contract management

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION SCHEME

8.0 DBMS/network/file management
- 8.1 Database management systems
- 8.2 Network/communication/file managers
- 8.3 Middleware

0.0 Miscellaneous

APPLICATION DEVELOPMENT, REENGINEERING, AND MAINTENANCE TOOL CLASSIFICATION RELATIONSHIPS



1.0 EXISTING SYSTEMS

3.0 NEW/REPLACEMENT SYSTEMS

1.1 ENHANCEMENT

1.2 ASSESSMENT

1.3 CONDITIONING

6.0 TESTING/ VALIDATION

3.1 3.2 PLANNING, ANALYSIS AND DESIGN (BPA and BPR)

3.3 3.4 DEVELOPMENT TOOLSETS

3.5 PROTOTYPING AND SIMULATION

4.2 REPOSITORY MANAGER

4.3 DATA WAREHOUSE

2.0 REPOSITORY LOAD AND ENHANCEMENT

FILE 4.1 REPOSITORY

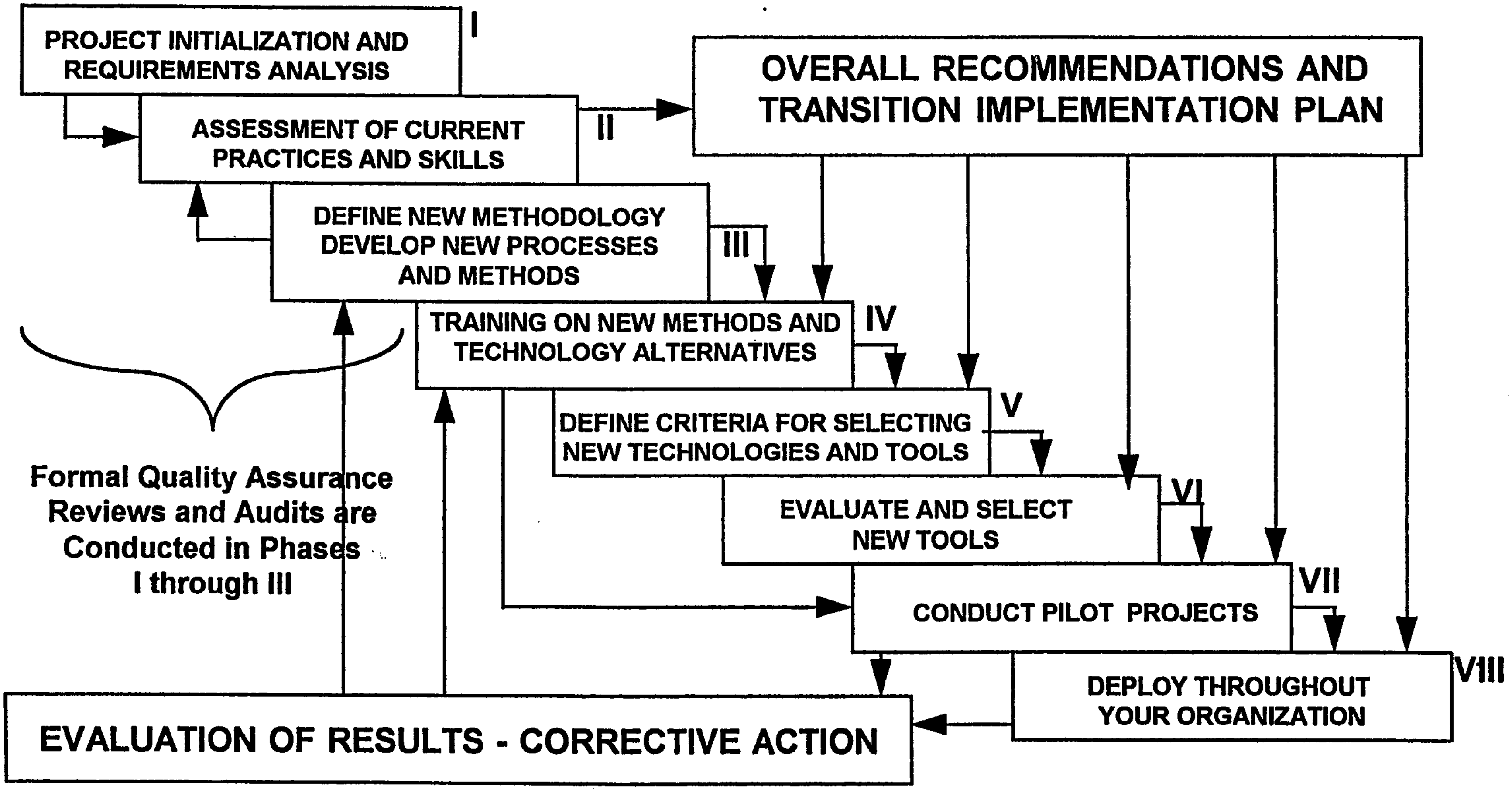
CODE LEVEL

SPEC LEVEL

8.0 DBMS/Network/File Management

7.0 SOFTWARE/PROJECT MANAGEMENT

BUSINESS/SYSTEM PROCESS IMPROVEMENT PROGRAM



PROJECT INITIALIZATION AND REQUIREMENTS ANALYSIS

ASSESSMENT OF CURRENT PRACTICES AND SKILLS

OVERALL RECOMMENDATIONS AND TRANSITION IMPLEMENTATION PLAN

DEFINE NEW METHODOLOGY DEVELOP NEW PROCESSES AND METHODS

TRAINING ON NEW METHODS AND TECHNOLOGY ALTERNATIVES

DEFINE CRITERIA FOR SELECTING NEW TECHNOLOGIES AND TOOLS

EVALUATE AND SELECT NEW TOOLS

CONDUCT PILOT PROJECTS

DEPLOY THROUGHOUT YOUR ORGANIZATION

EVALUATION OF RESULTS - CORRECTIVE ACTION

Formal Quality Assurance Reviews and Audits are Conducted in Phases I through III

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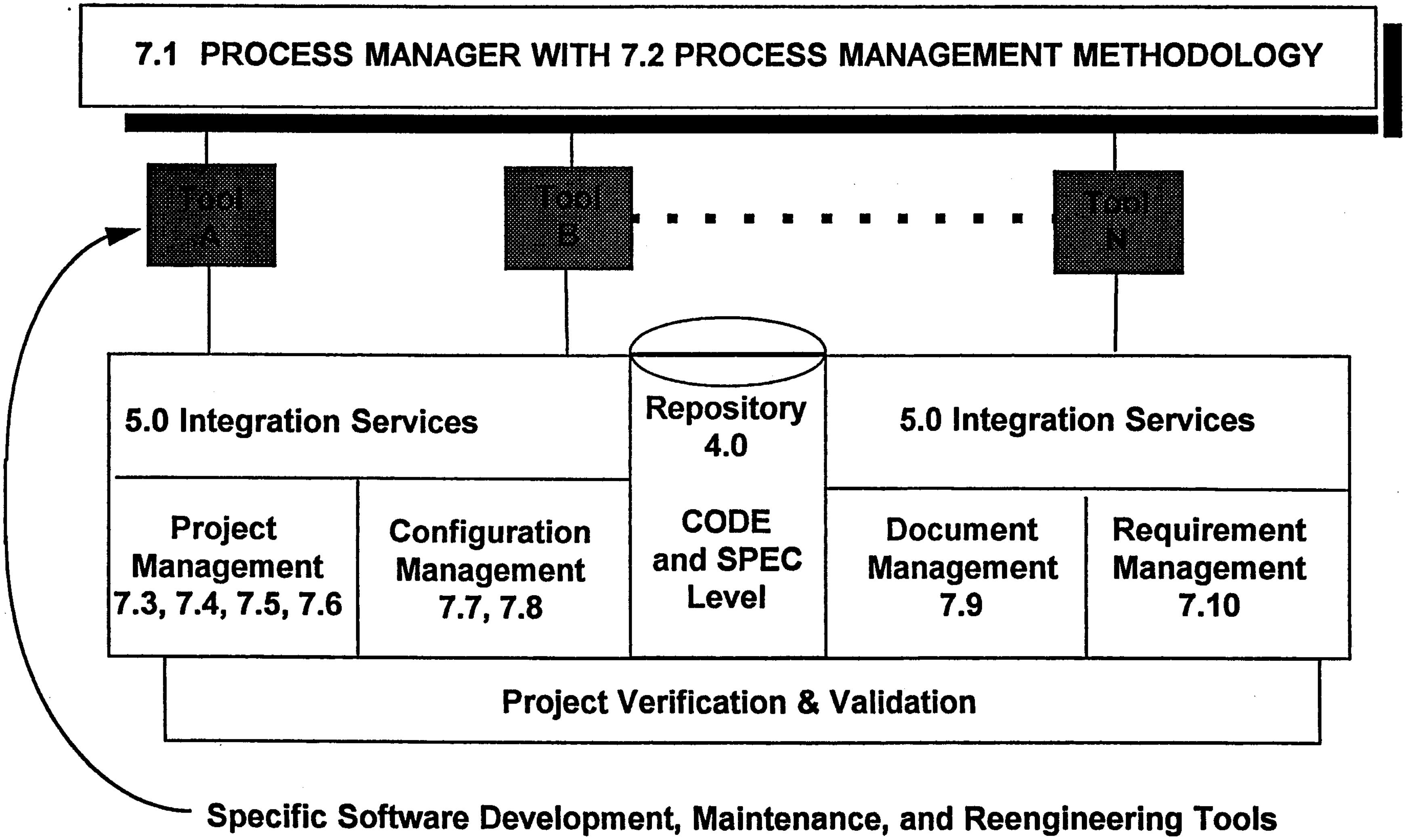
TOOLS AND SOLUTIONS FOR MANAGING SYSTEMS TRANSITIONS

Implement the fundamentals of engineering first around a repository

- Configuration management
- Project management
- Process management
- Team coordination and information sharing
- Project verification and validation
- Documentation management

A FRAMEWORK FOR SOFTWARE ENGINEERING MANAGEMENT



7.1 PROCESS MANAGER WITH 7.2 PROCESS MANAGEMENT METHODOLOGY

5.0 Integration Services

Project Management 7.3, 7.4, 7.5, 7.6

Configuration Management 7.7, 7.8

Repository 4.0

CODE and SPEC Level

5.0 Integration Services

Document Management 7.9

Requirement Management 7.10

Project Verification & Validation

Specific Software Development, Maintenance, and Reengineering Tools

Appendix A

TOOL CLASSIFICATION SCHEME DEFINITIONS

1.0 EXISTING SYSTEMS

- 1.1 ENHANCEMENT
  - 1.1.1 SMART EDITORS/BROWSERS
  - 1.1.2 MAINTENANCE ENVIRONMENT
- 1.2 ASSESSMENT
  - 1.2.1 MEASUREMENT
  - 1.2.2. INVENTORY/ANALYSIS
  - 1.2.3 RE-DOCUMENTATION
- 1.3 CONDITIONING
  - 1.3.1 DATA RATIONALIZATION
  - 1.3.2 PROCESS RATIONALIZATION
  - 1.3.3 CONVERSION/MIGRATION
  - 1.3.4 CODE (PROCESS) RESTRUCTURING

Examine existing system components at the code level to provide information about the software for making changes (maintenance) and current system confirmation for new development (software verification and validation)

1.1 ENHANCEMENT - for understanding an existing system before making changes

1.1.1 SMART EDITORS/BROWSERS - for analysis of structure, organization, data usage and relationships and logical execution paths within one or more programs.

1.1.2 MAINTENANCE ENVIRONMENT - combine the capabilities of smart editors and browsers with a code level repository for analysis in or between programs, screens, JCL, databases, and TP monitors.

1.2 ASSESSMENT - examine the source code components of existing systems by measuring the characteristics of the components, creating an inventory and classification of the components, and creating documentation. This is a discovery process during which no changes are made to the source code.

1.2.1 MEASUREMENT - parse through source code and generate a variety of metrics.

1.2.2. INVENTORY/ANALYSIS - parse through source code to locate, identify and analyze existing system components.

1.2.3 RE-DOCUMENTATION - parse through source code and build system documentation.

1.3 CONDITIONING - automate the process of improving (changing) the code itself by passing through the source code, sometimes using a special purpose repository, to change the code. Tools of this class can be used as a preconditioning step to Repository Load/Enhancement (Tool Class 2.0)

1.3.1 DATA RATIONALIZATION - analyze data structures and data usage within one or more programs and support the adherence to standards and removal of redundancy (homonyms and alias)

1.3.2 PROCESS RATIONALIZATION - analyze process isolation, reuse, and modularization characteristics with programs and support the changes to these structural components.

1.3.3 **CONVERSION/MIGRATION - translate (change) source code for languages, databases, and teleprocessing environments.**

1.3.4 **CODE (PROCESS) RESTRUCTURING - parse source code, analyze the control flow, and correct the programs structure.**

2.0 **REPOSITORY LOAD/ENHANCEMENT - parse source code for both data and processes and translate the code into the information models of a target tool repository.**

2.1 **DATA**

2.2 **PROCESS**

3.0 **NEW/REPLACEMENT SYSTEMS - support the development of new and replacement systems using the Information Engineering or some other life cycle methodology. This class is comprised of the sub classes 3.1 Planning, 3.2 Analysis and Design, 3.3 Construction/Generation, 3.4 GUI Builders, 3.5 Prototyping/Simulation, and 3.9 MetaCASE Tools. Tools for modeling workflows and business processes are part of Planning (Class 3.1).**

4.0 REPOSITORIES - the tool repositories and data dictionaries which facilitate the reengineering (replacement) of existing systems or the new development of replacement systems. These are the repositories found as part of tools in Classes 1.1.2 Maintenance Environment, 2.0 Repository Load/Enhancement, and 3.0 New/Replacement Systems.

4.1 TOOL REPOSITORIES/DATA DICTIONARIES - the specific repositories found in tool classes 1.1.2, 2.0, and 3.0

4.2 REPOSITORY/DATA DICTIONARY MANAGERS - support the definition of many information models, can establish and maintain the objects comprising these models, and can manage the reuse of objects.

4.3 DATA WAREHOUSES

5.0 **INTEGRATED TOOLSET ENVIRONMENT** - those tools that allow for the integration of different tools into an environment, allow two or more tools to exchange data or pass control information, and those tools from a single vendor which span multiple tool classes.

5.1 **INTEGRATION FRAMEWORKS** - tools which serve as an integrated project support environment (IPSE) for integrating multiple tools into a common environment.

5.2 **INTEGRATION UTILITIES** - tools supporting the transfer of data between two or more tools or two or more tool repositories.

5.3 **RESULTING INTEGRATED TOOLS** - those tools typically from different vendors in Classes 1.0 through 4.0 and 6.0 through 8.0 which are integrated by frameworks or utilities.

5.4 **ICASE TOOLS** - a toolset typically from one vendor.

6.0 **TESTING/VALIDATION - those tools that ensure a system operates as expected or as defined by system requirements.**

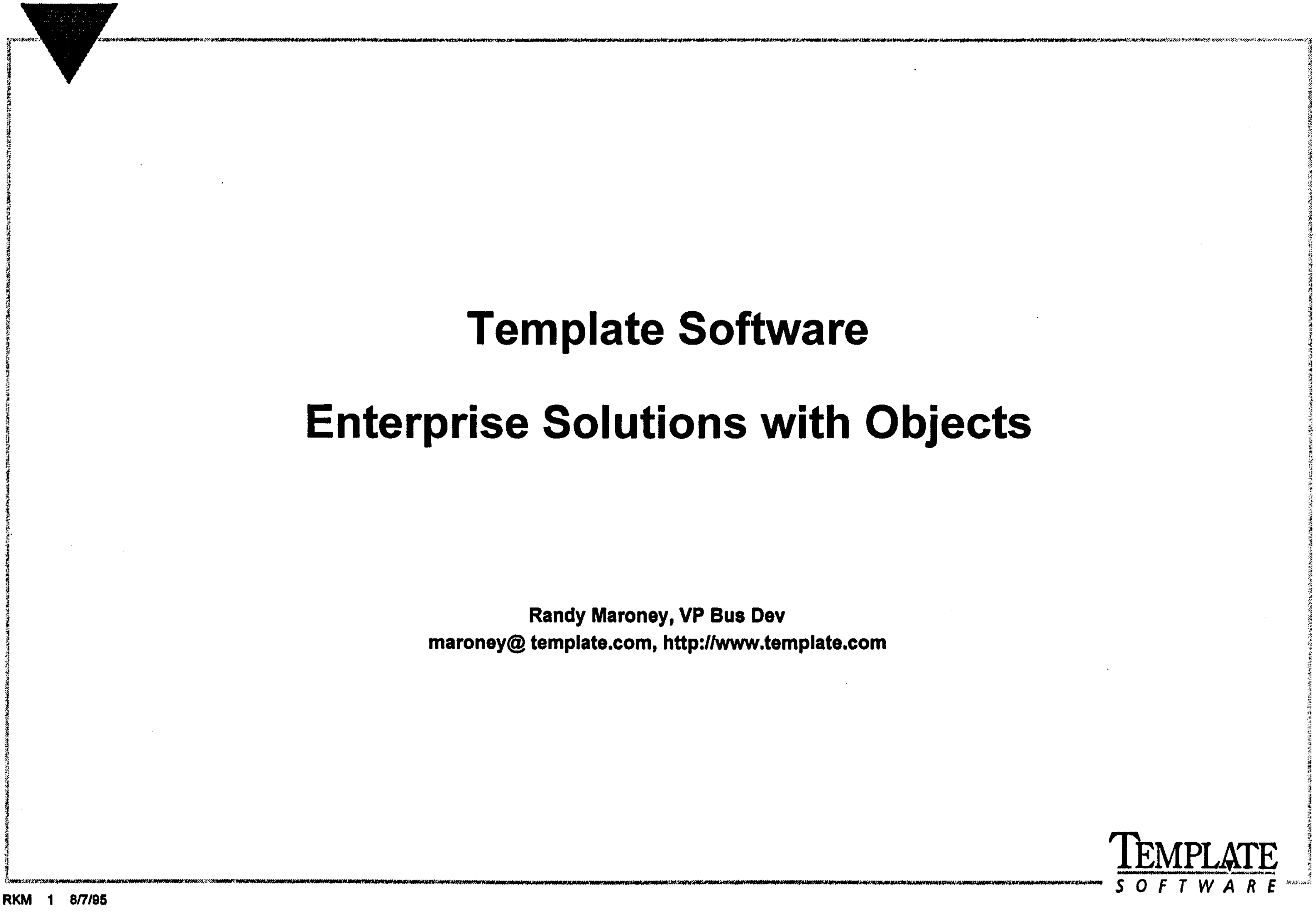
6.1 TEST PLANNING AND MANAGEMENT
6.2 TEST DATA GENERATION
6.3 EXECUTION/TESTING
6.4 CAPTURE/PLAYBACK
6.5 COVERAGE ANALYSIS
6.6 VALIDATION/CORRECTION
6.7 CODE/DATA COMPARISON
6.8 GUI TESTERS

7.0 SOFTWARE/PROJECT MANAGEMENT

- 7.1 PROCESS WORKBENCHES AND WORKFLOW MANAGERS
- 7.2 PROCESS METHODOLOGIES
- 7.3 PROJECT MANAGEMENT
- 7.4 ESTIMATION/PROJECTION
- 7.5 JOB ACCOUNTING/CHARGEBACK
- 7.6 PERFORMANCE MANAGEMENT
- 7.7 PROBLEM TRACKING
- 7.8 CONFIGURATION/CHANGE/VERSION MANAGEMENT
- 7.9 DOCUMENT MANAGEMENT AND IMAGING
- 7.10 REQUIREMENTS MANAGEMENT
- 7.11 OPERATIONS MANAGEMENT
- 7.12 TRAINING
- 7.13 ACQUISITION/CONTRACT MANAGEMENT

8.0 DBMS/NETWORK/FILE MANAGEMENT

0.0 MISCELLANEOUS



Template Software

Enterprise Solutions with Objects

Randy Maroney, VP Bus Dev
maroney@ template.com, http://www.template.com

TEMPLATE
SOFTWARE

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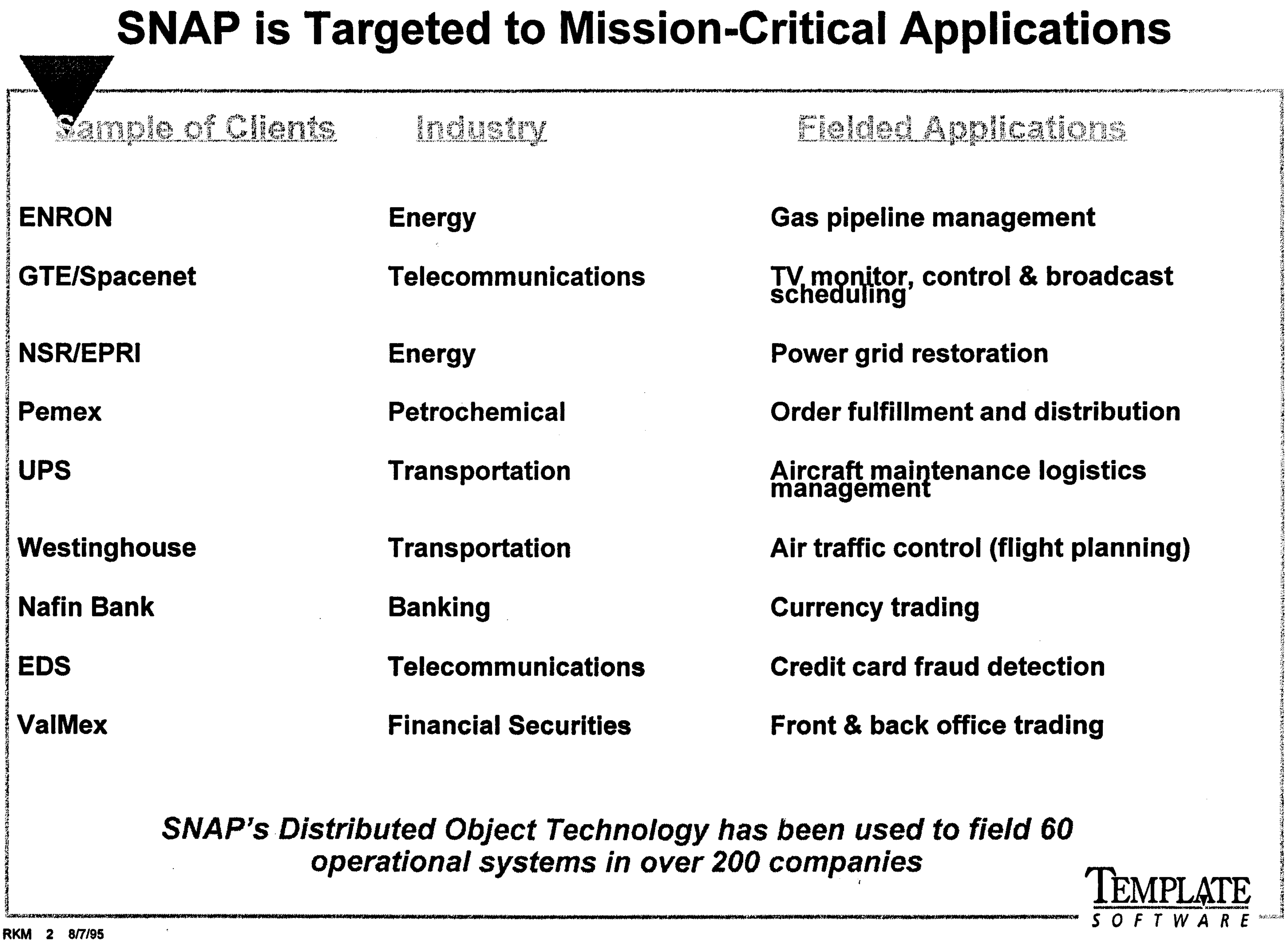

SNAP is Targeted to Mission-Critical Applications

Sample of Clients	Industry	Fielded Applications
ENRON	Energy	Gas pipeline management
GTE/Spacenet	Telecommunications	TV monitor, control & broadcast scheduling
NSR/EPRI	Energy	Power grid restoration
Pemex	Petrochemical	Order fulfillment and distribution
UPS	Transportation	Aircraft maintenance logistics management
Westinghouse	Transportation	Air traffic control (flight planning)
Nafin Bank	Banking	Currency trading
EDS	Telecommunications	Credit card fraud detection
ValMex	Financial Securities	Front & back office trading

SNAP's Distributed Object Technology has been used to field 60 operational systems in over 200 companies

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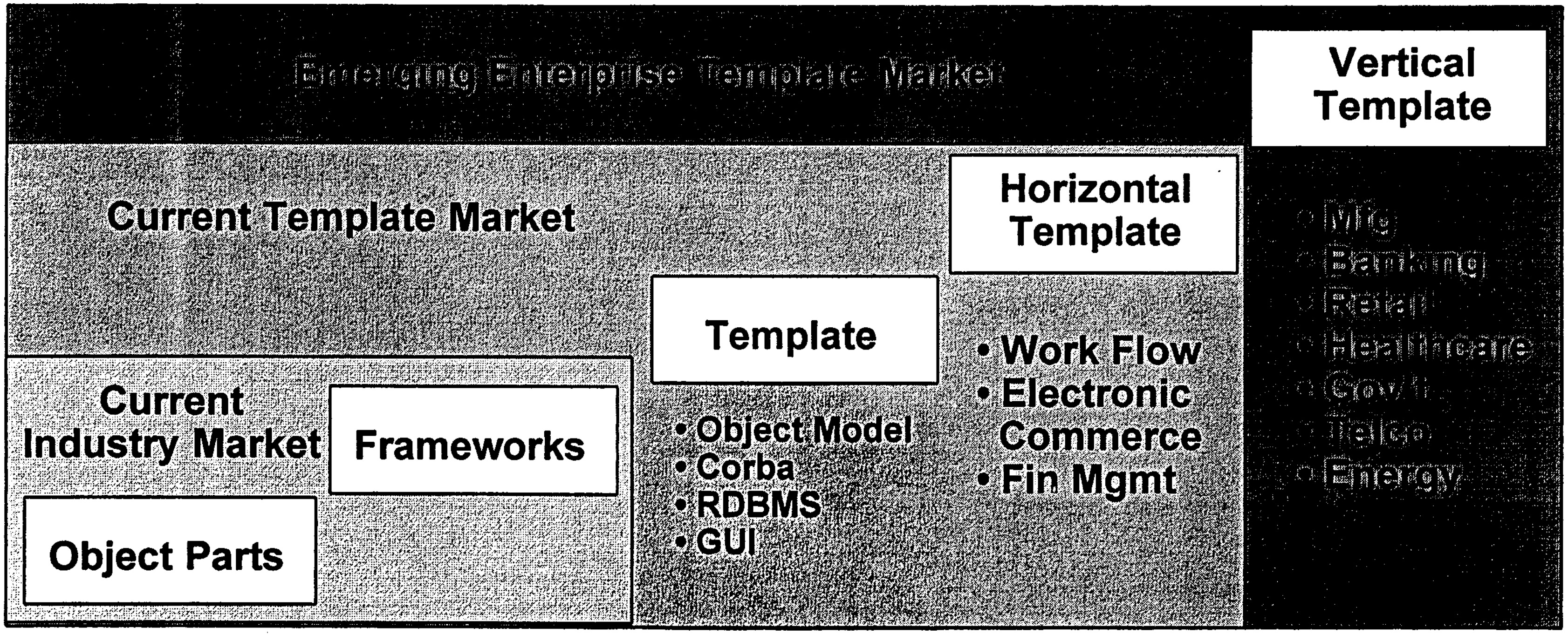
OO Technology Evolution



Emerging Enterprise Template Market

Vertical Template

- Mfg
- Banking
- Retail
- Healthcare
- Gov't
- Telco
- Energy

Current Template Market

Horizontal Template

- Work Flow
- Electronic Commerce
- Fin Mgmt

Template

- Object Model
- Corba
- RDBMS
- GUI

Current Industry Market

Frameworks

Object Parts

- C++ Lib
- 3GL

- APIs
- Programmer

- Integrated Architecture
- Visual Application Gen
- Plug & Play Frameworks
- Cross Industry Reuse

- Industry Specific
- Enterprise FWs
- Business Models

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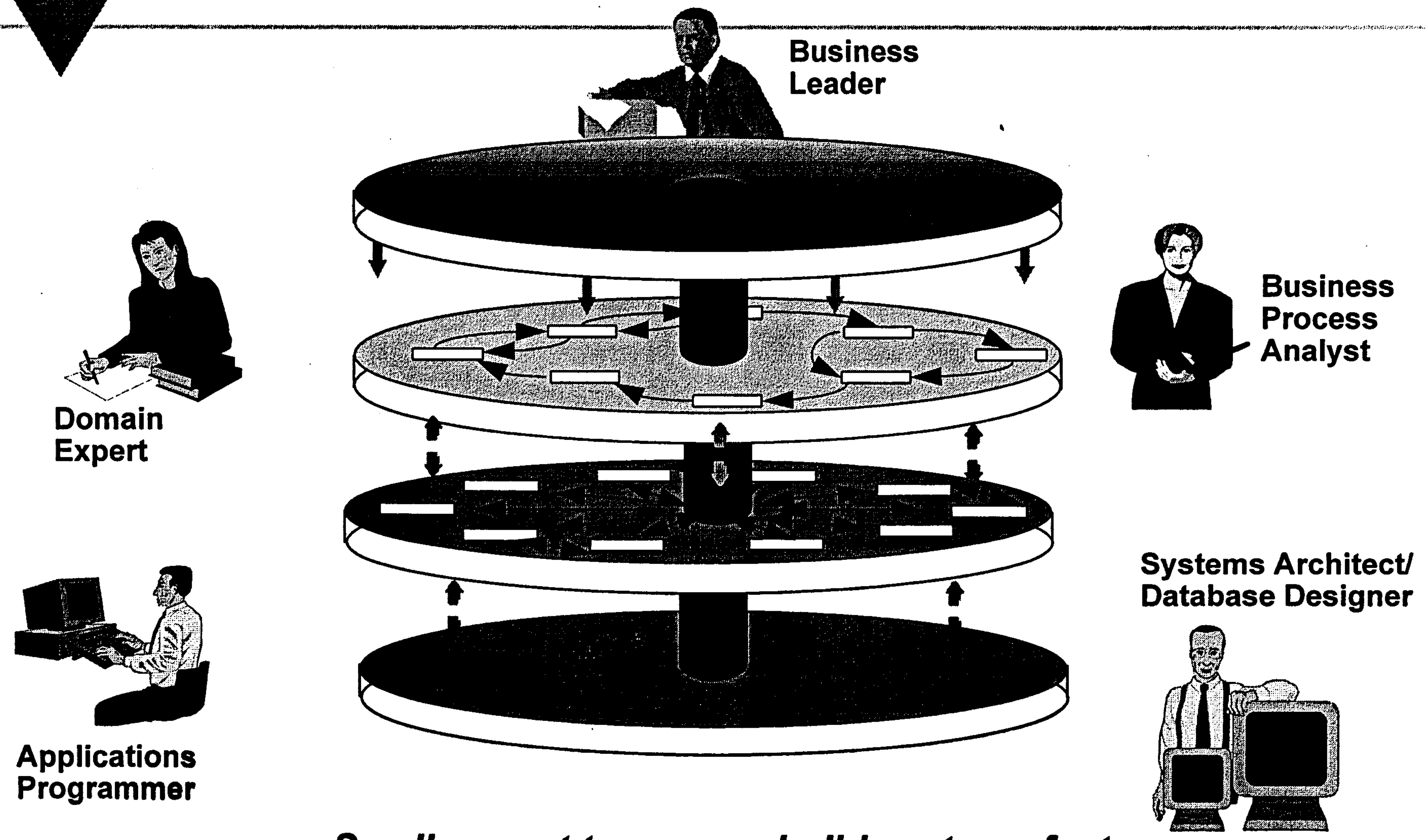
Mobilizing Skills From Across the Enterprise



Small, expert teams can build systems fast using the Template Technology Strategy

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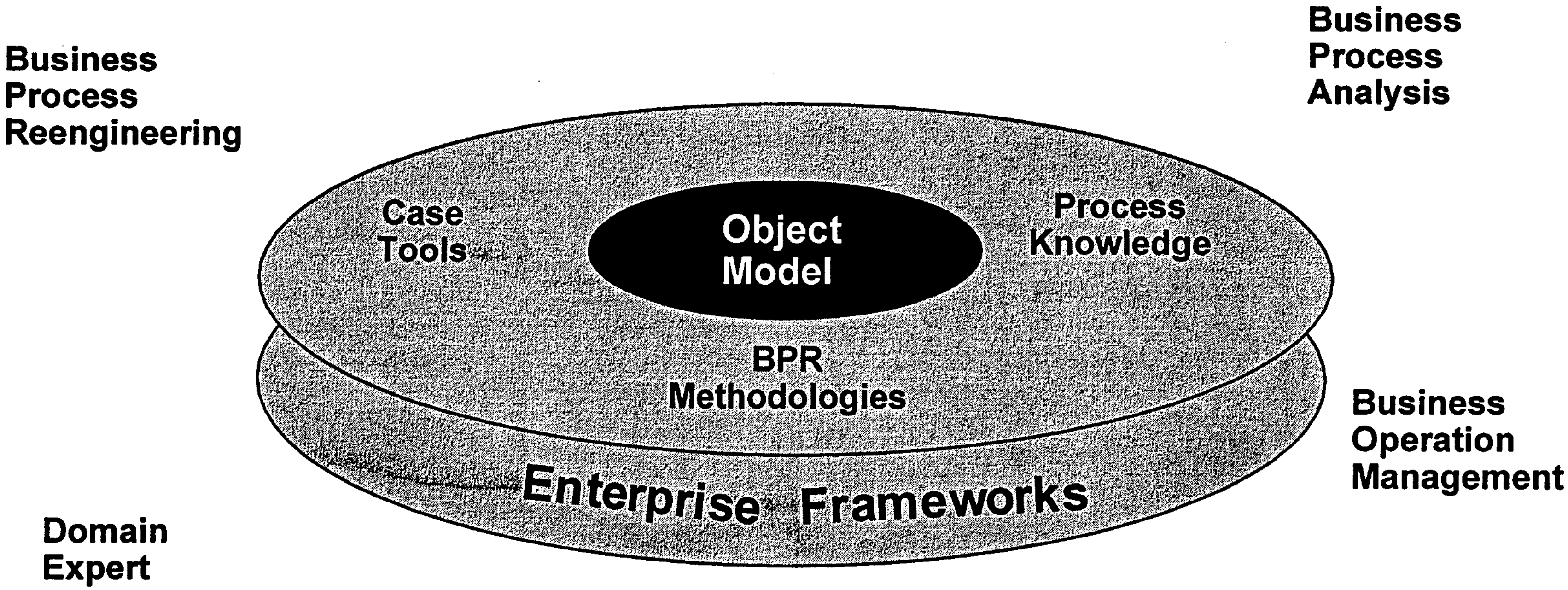
Business Knowledge Layer in the Template Environment



Template supports knowledge input from many sources

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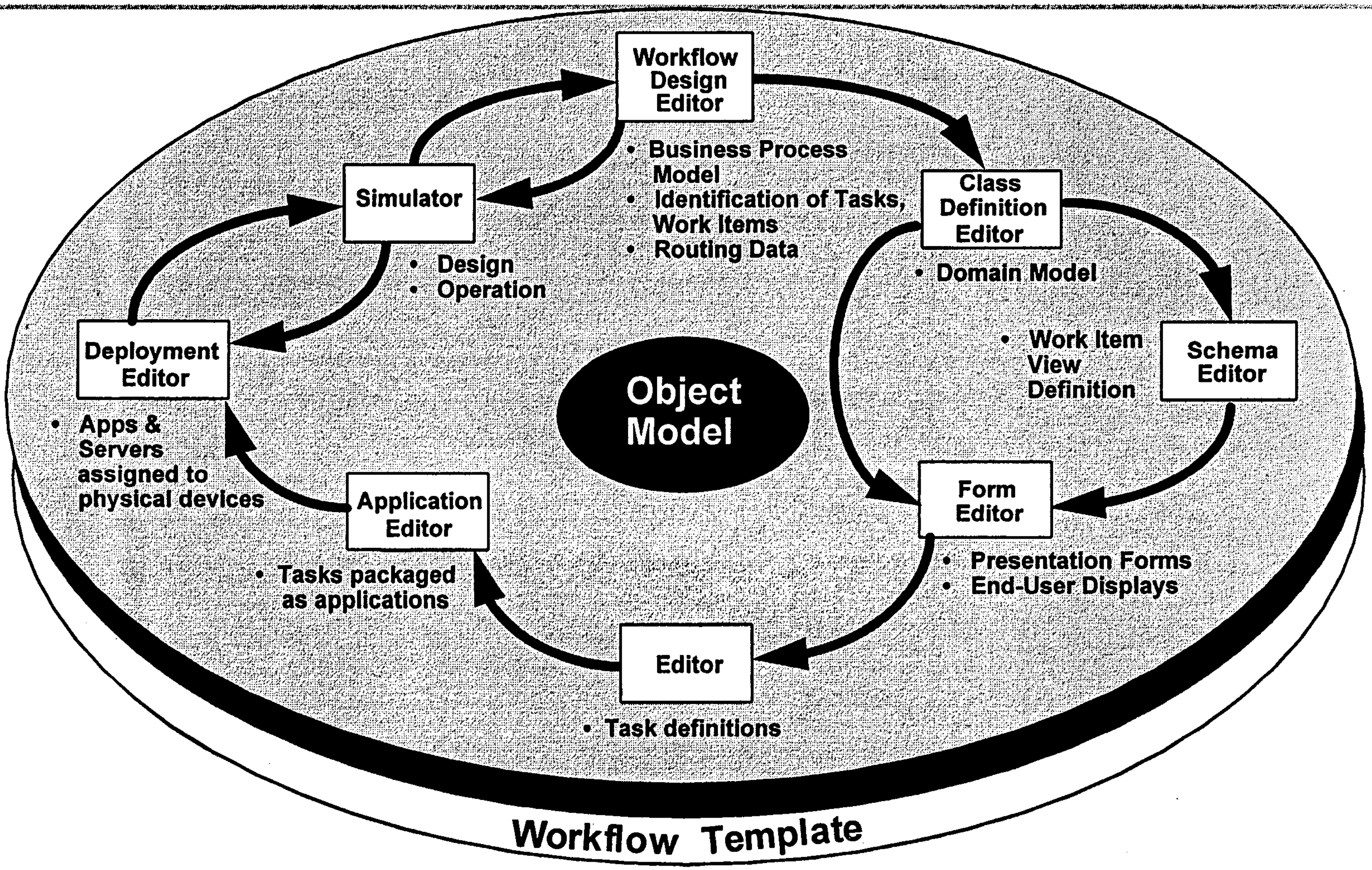
Visual Business Programming Layer



The system can change with the business needs, typically in 4-8 week iterative cycles

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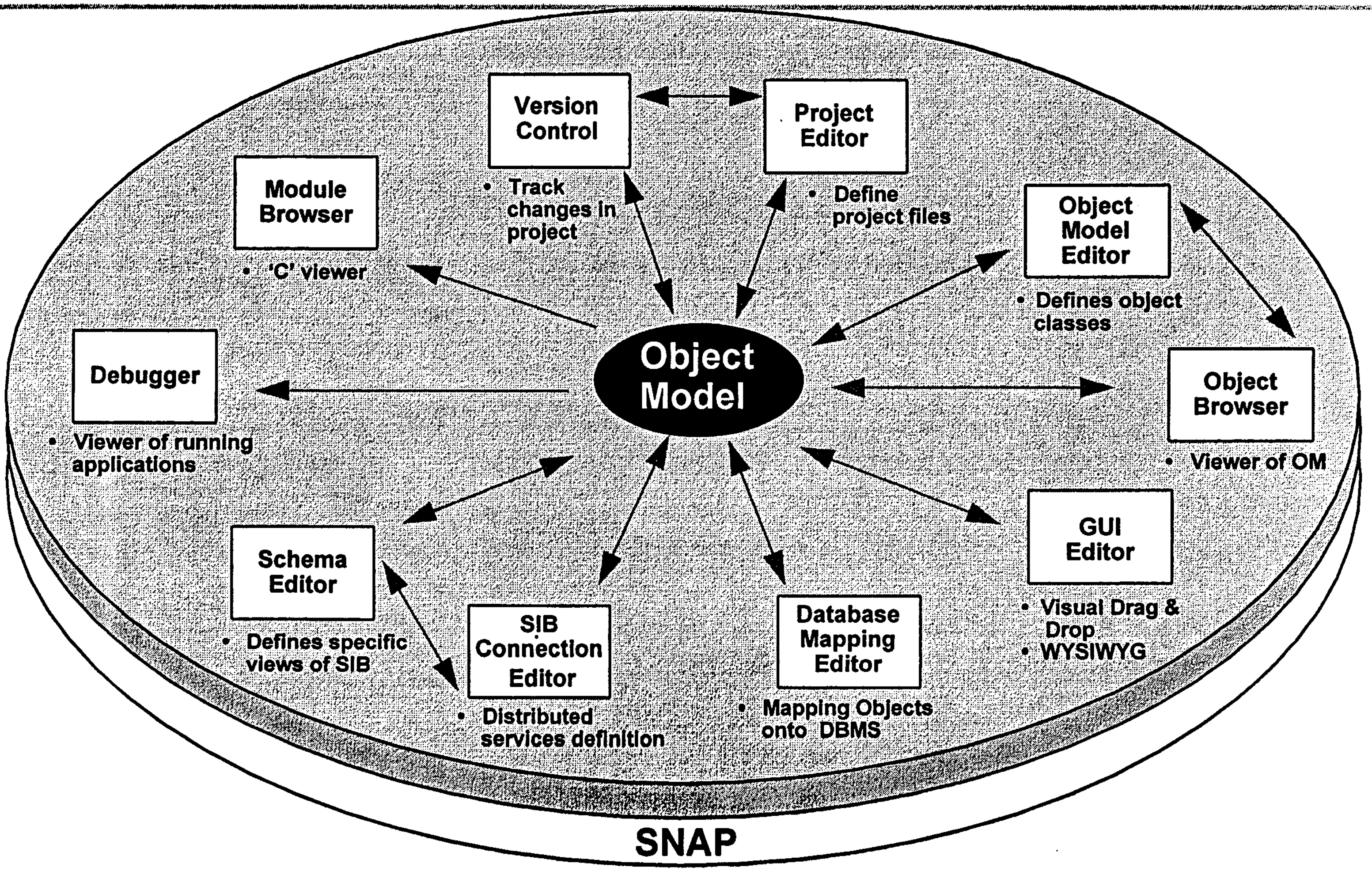
Object Programming Layer in the Template Environment



SNAP provides a full set of project development tools centered on the object model ensuring ultra-high productivity

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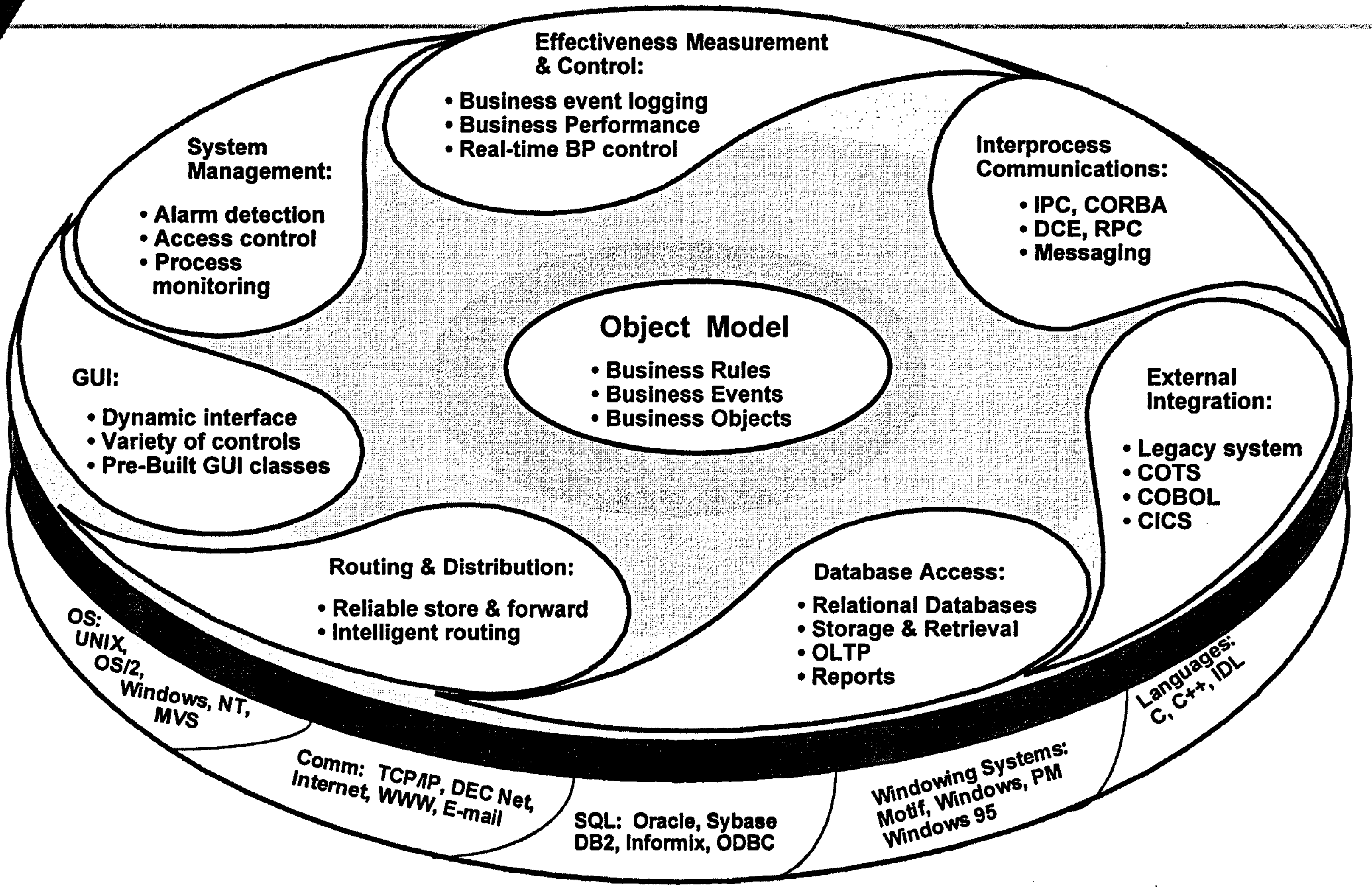
Infrastructure Layer in the Template Environment



Effectiveness Measurement & Control:

- Business event logging
- Business Performance
- Real-time BP control

System Management:

- Alarm detection
- Access control
- Process monitoring

Interprocess Communications:

- IPC, CORBA
- DCE, RPC
- Messaging

Object Model

- Business Rules
- Business Events
- Business Objects

GUI:

- Dynamic interface
- Variety of controls
- Pre-Built GUI classes

External Integration:

- Legacy system
- COTS
- COBOL
- CICS

Routing & Distribution:

- Reliable store & forward
- Intelligent routing

Database Access:

- Relational Databases
- Storage & Retrieval
- OLTP
- Reports

OS: UNIX, OS/2, Windows, NT, MVS

Comm: TCP/IP, DEC Net, Internet, WWW, E-mail

SQL: Oracle, Sybase DB2, Informix, ODBC

Windowing Systems: Motif, Windows, PM Windows 95

Languages: C, C++, IDL

Specialized business processes and objects are portable and scaleable across the infrastructure

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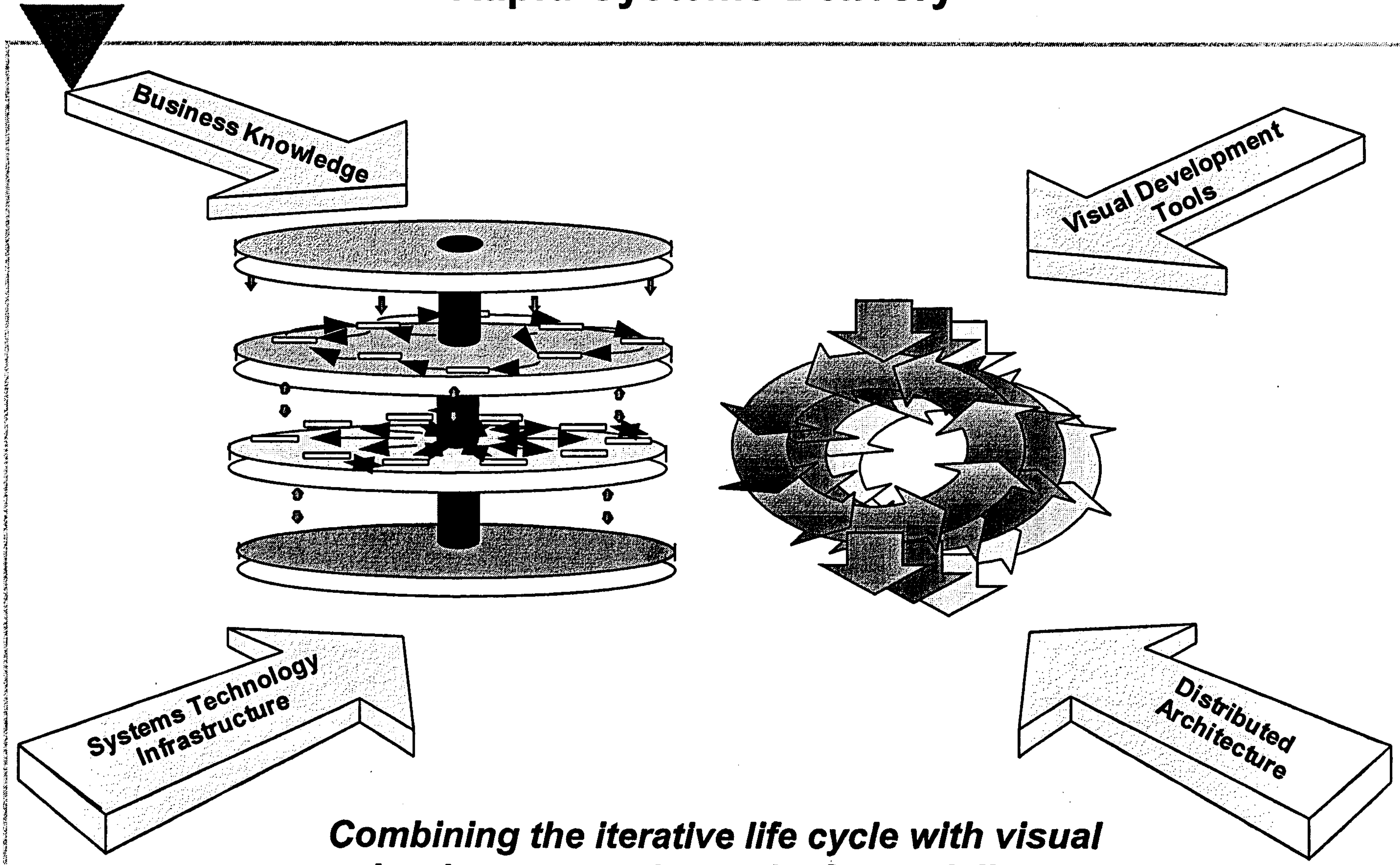
Rapid Systems Delivery



Combining the iterative life cycle with visual development tools results faster delivery

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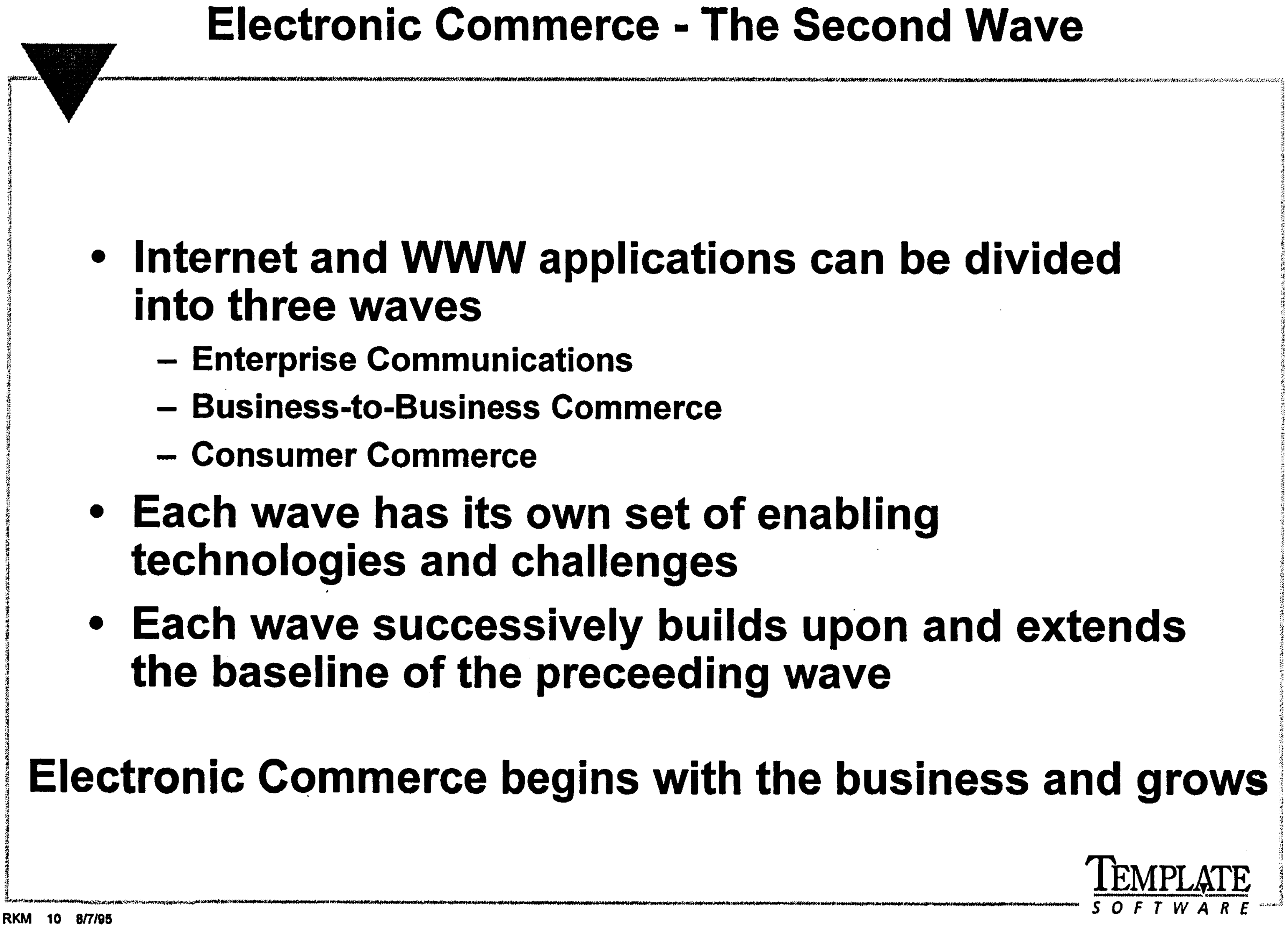

Electronic Commerce - The Second Wave

- Internet and WWW applications can be divided into three waves
  - Enterprise Communications
  - Business-to-Business Commerce
  - Consumer Commerce
- Each wave has its own set of enabling technologies and challenges
- Each wave successively builds upon and extends the baseline of the preceeding wave

Electronic Commerce begins with the business and grows

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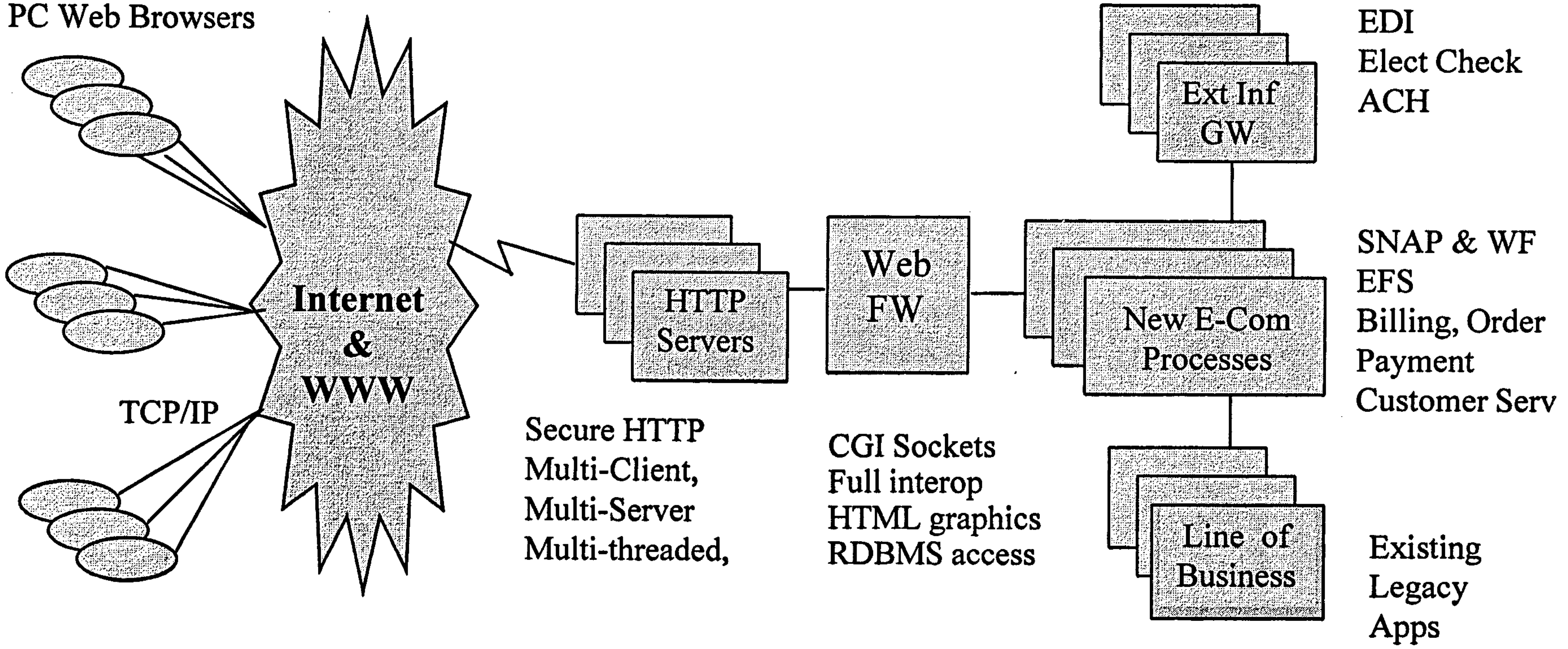
Online Internet Architecture

Front End

Middle

Back End



PC Web Browsers

Internet & WWW

TCP/IP

HTTP Servers

Secure HTTP
Multi-Client,
Multi-Server
Multi-threaded,

Web FW

CGI Sockets
Full interop
HTML graphics
RDBMS access

Ext Inf GW

EDI
Elect Check
ACH

New E-Com Processes

SNAP & WF
EFS
Billing, Order
Payment
Customer Serv

Line of Business

Existing
Legacy
Apps

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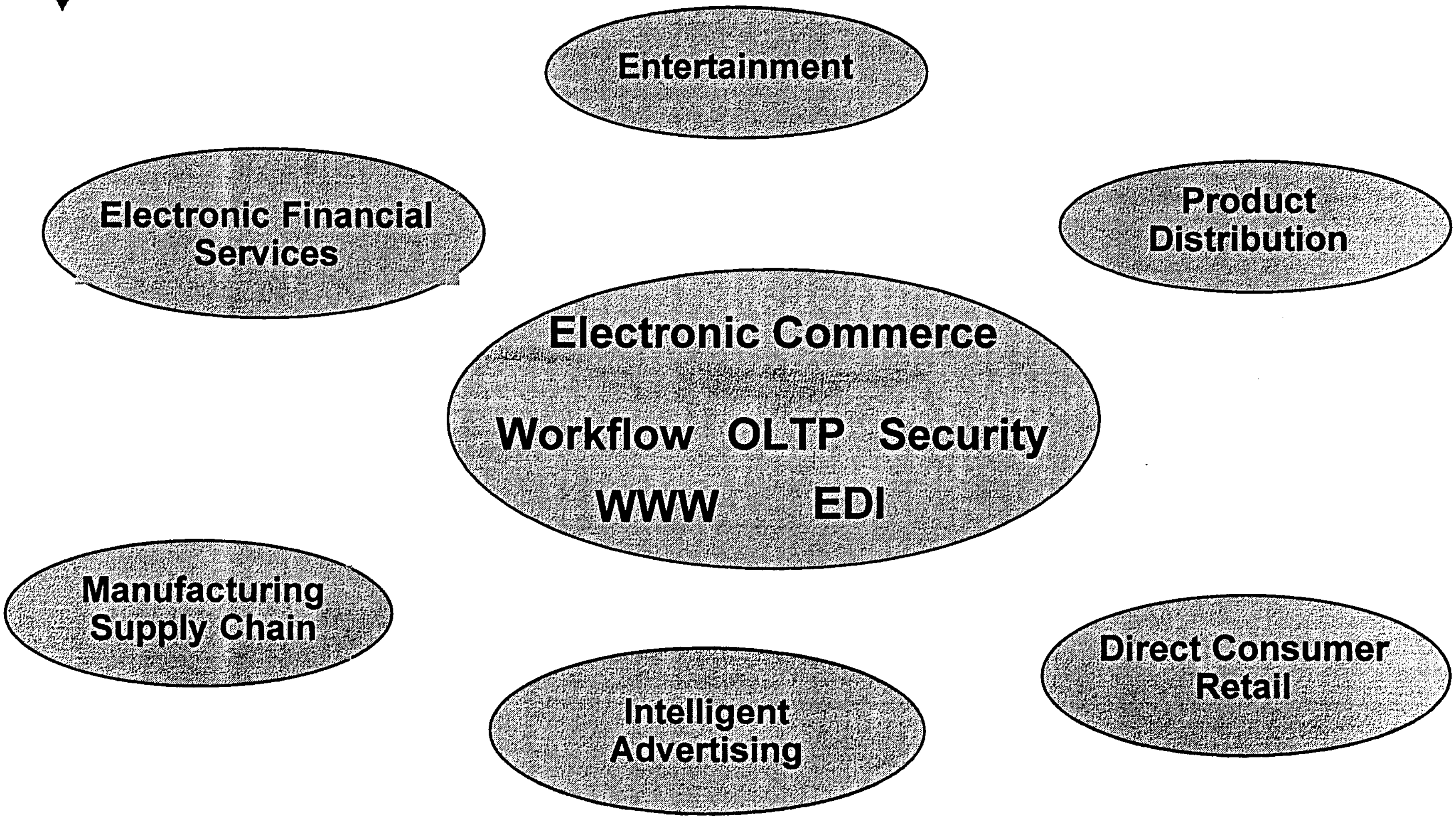
Electronic Commerce Market Scope



Entertainment

Electronic Financial Services

Product Distribution

Electronic Commerce

Workflow OLTP Security

WWW EDI

Manufacturing Supply Chain

Intelligent Advertising

Direct Consumer Retail

TEMPLATE SOFTWARE

RKM 12 8/7/96

Using Electronic Commerce in New Markets

- Business to Business
- Business to Consumer
- Consumer to Business
- All business transactions
  - Orders and subscriptions
  - Billing and Payments
  - Supplier Interaction
  - Distribution Providers
  - Customer Account Services
  - Field Service
  - Electronic Advertising

- PC access via Web
- Full Security
  - Privacy
  - Access
  - Non-repudiation
- Interactive
- Integrated with Legacy Line of Business Apps
- Integrated with Electronic Financial services

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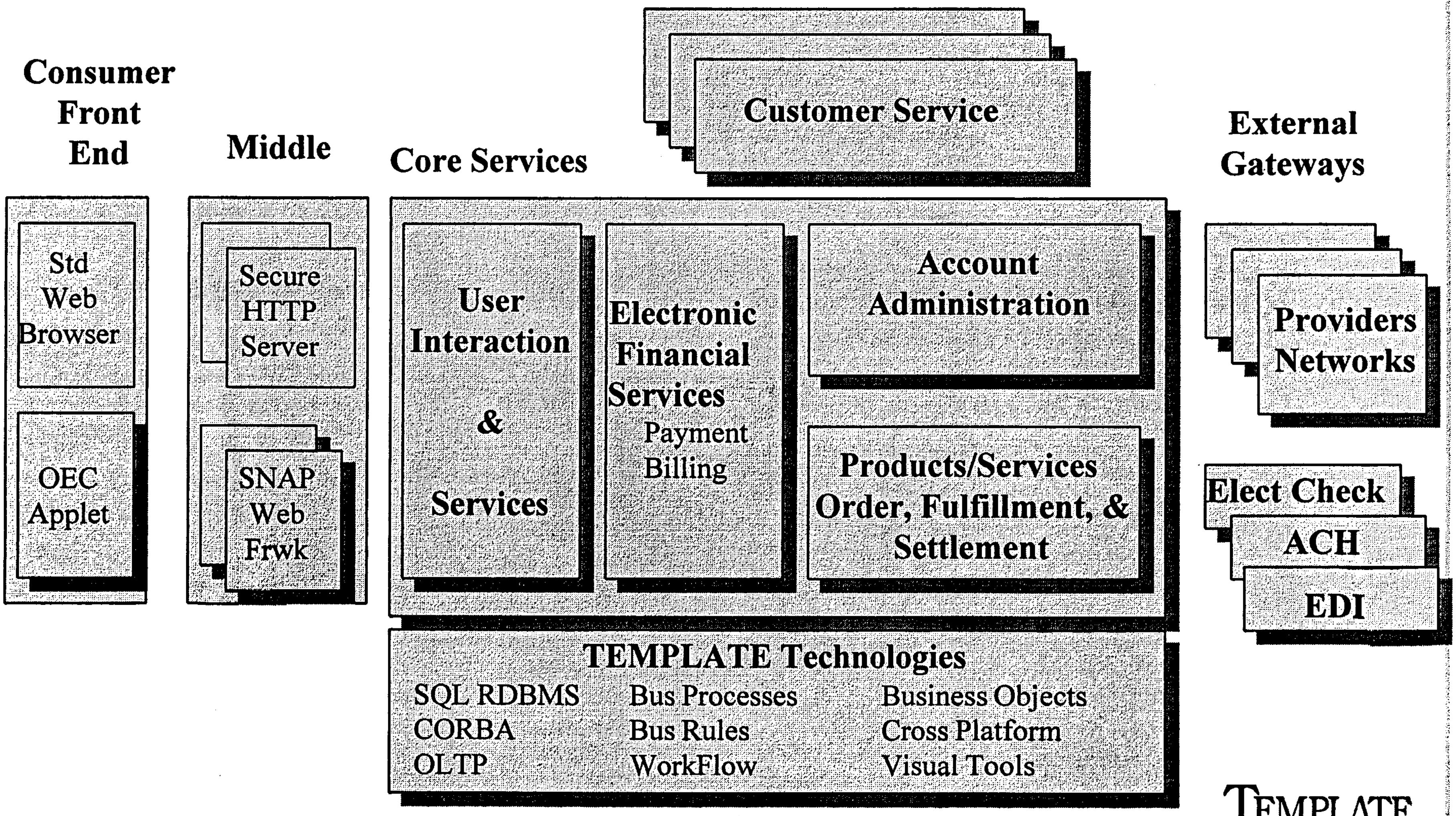
RKM 13 8/7/95

Electronic Commerce Application Architecture



Consumer Front End

Std Web Browser

OEC Applet

Middle

Secure HTTP Server

SNAP Web Frwk

Core Services

Customer Service

User Interaction & Services

Electronic Financial Services
Payment
Billing

Account Administration

Products/Services Order, Fulfillment, & Settlement

TEMPLATE Technologies

SQL RDBMS
CORBA
OLTP

Bus Processes
Bus Rules
WorkFlow

Business Objects
Cross Platform
Visual Tools

External Gateways

Providers Networks

Elect Check

ACH

EDI

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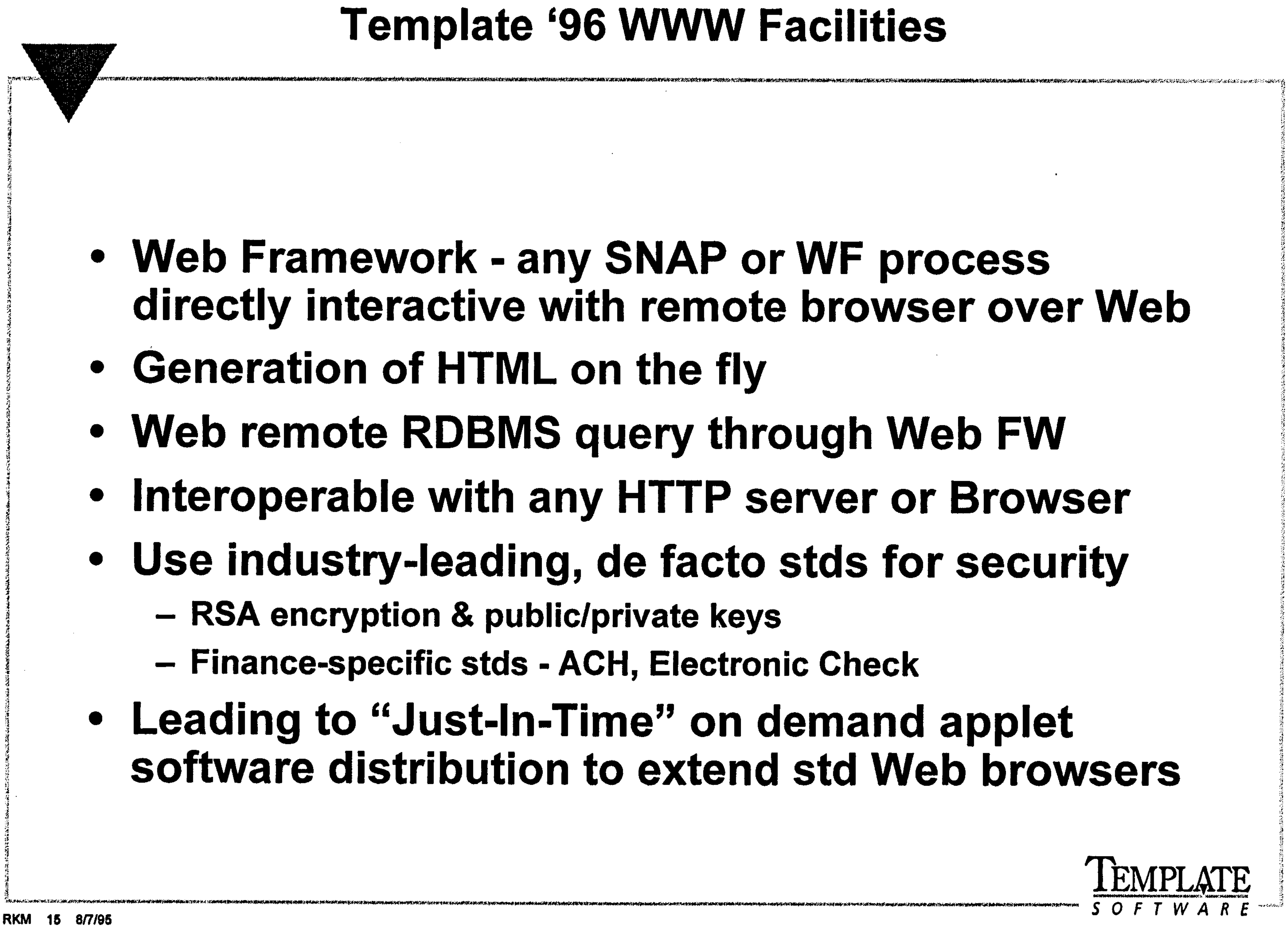

Template '96 WWW Facilities

- Web Framework - any SNAP or WF process directly interactive with remote browser over Web
- Generation of HTML on the fly
- Web remote RDBMS query through Web FW
- Interoperable with any HTTP server or Browser
- Use industry-leading, de facto stds for security
  - RSA encryption & public/private keys
  - Finance-specific stds - ACH, Electronic Check
- Leading to "Just-In-Time" on demand applet software distribution to extend std Web browsers

TEMPLATE SOFTWARE

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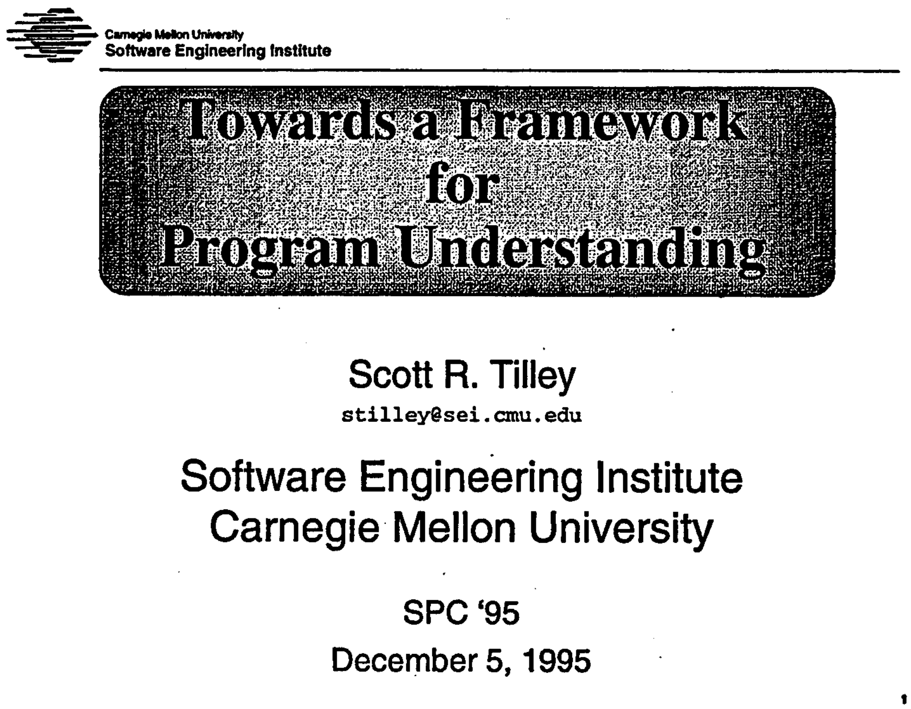
Summary

- Template and Customers are delivering large scale, high impact solutions
- Solutions leverage existing Template technology
- Object Technology has proven to be an effective reengineering approach
- Reengineering defines the Enterprise Business Objects
- Reengineering defines the Business Processes
- Reengineering and Template reuse architecture allows rapid, cost effective solution delivery

TEMPLATE SOFTWARE

RKM 16 8/7/95



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Towards a Framework for Program Understanding

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Software Engineering Institute
Carnegie Mellon University

SPC '95

December 5, 1995

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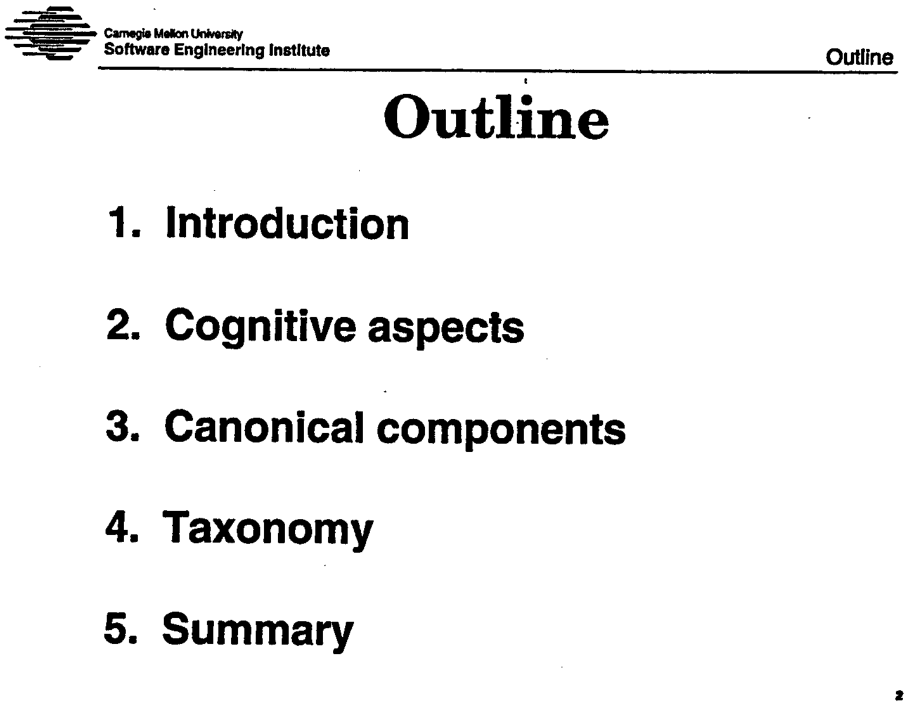

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Outline

Outline

1. Introduction
2. Cognitive aspects
3. Canonical components
4. Taxonomy
5. Summary

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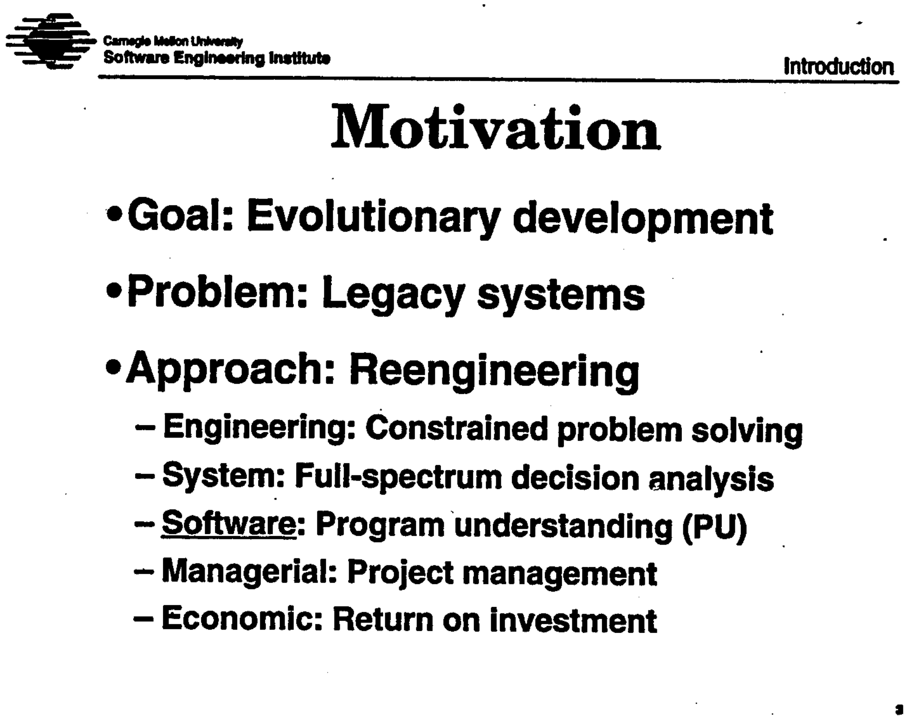

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Introduction

Motivation

- Goal: Evolutionary development
- Problem: Legacy systems
- Approach: Reengineering
  - Engineering: Constrained problem solving
  - System: Full-spectrum decision analysis
  - Software: Program understanding (PU)
  - Managerial: Project management
  - Economic: Return on investment

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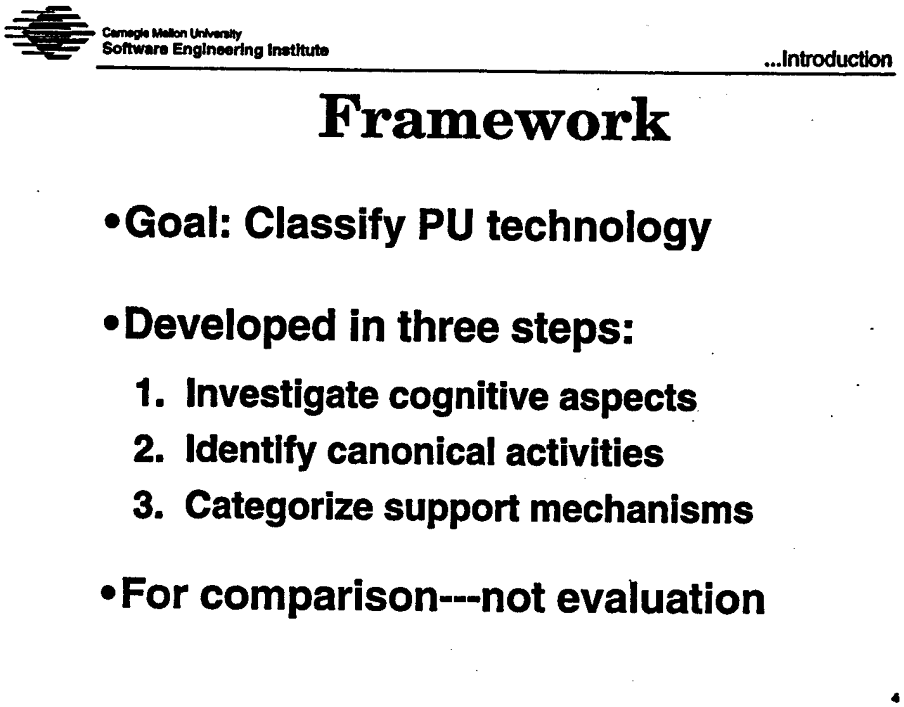

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...Introduction

Framework

- Goal: Classify PU technology
- Developed in three steps:
  1. Investigate cognitive aspects
  2. Identify canonical activities
  3. Categorize support mechanisms
- For comparison---not evaluation

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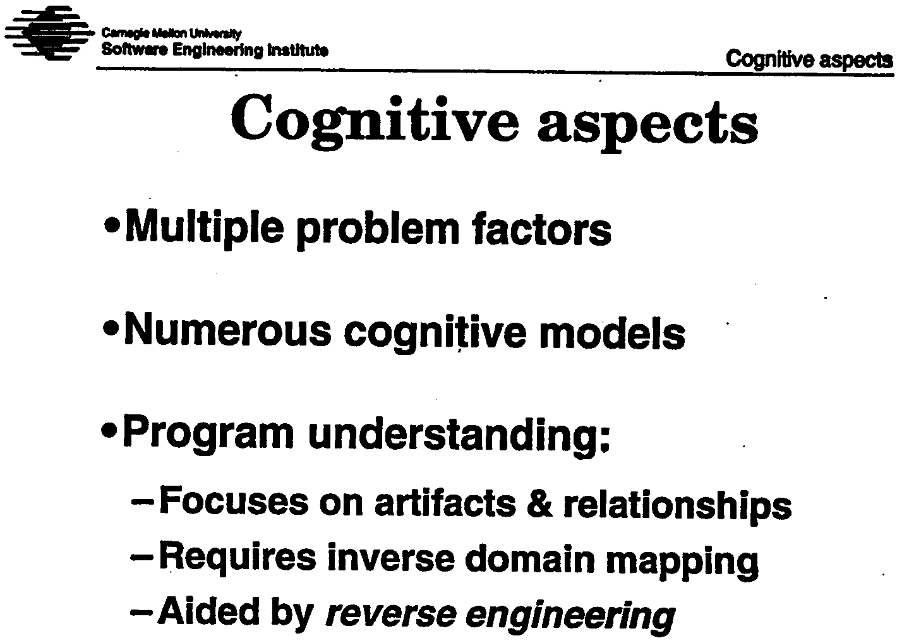

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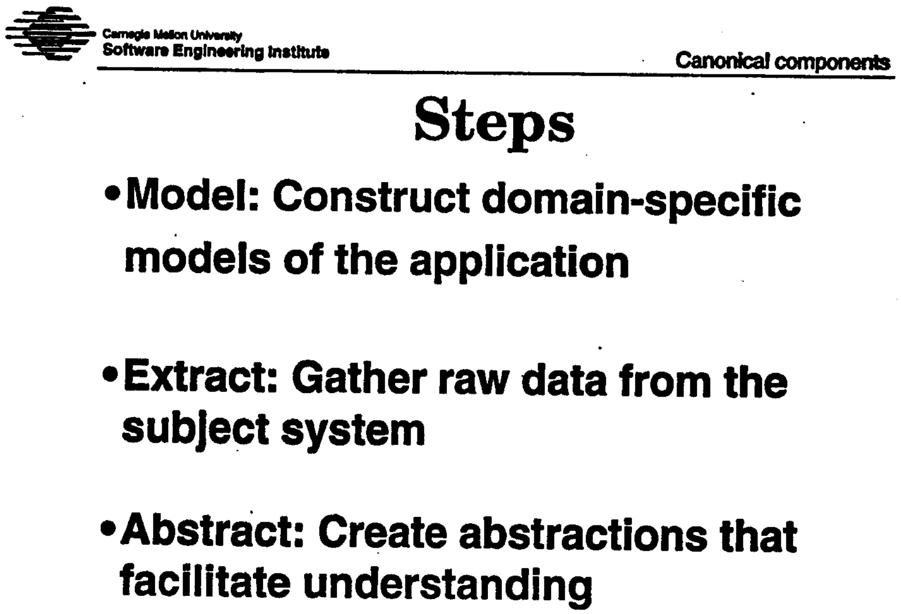
Cognitive aspects

Cognitive aspects

- Multiple problem factors
- Numerous cognitive models
- Program understanding:
  - Focuses on artifacts & relationships
  - Requires inverse domain mapping
  - Aided by *reverse engineering*



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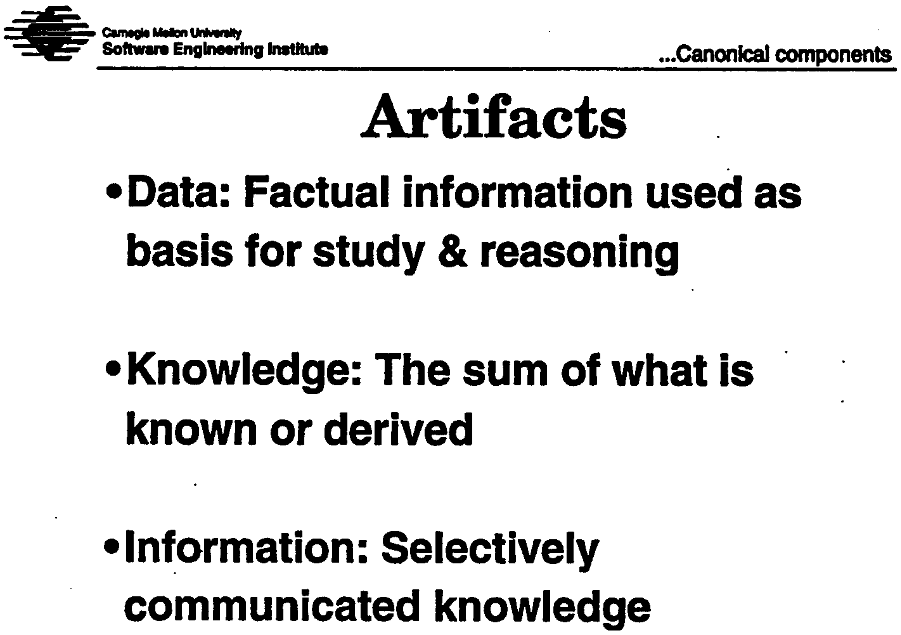
Canonical components

Steps

- Model: Construct domain-specific models of the application
- Extract: Gather raw data from the subject system
- Abstract: Create abstractions that facilitate understanding



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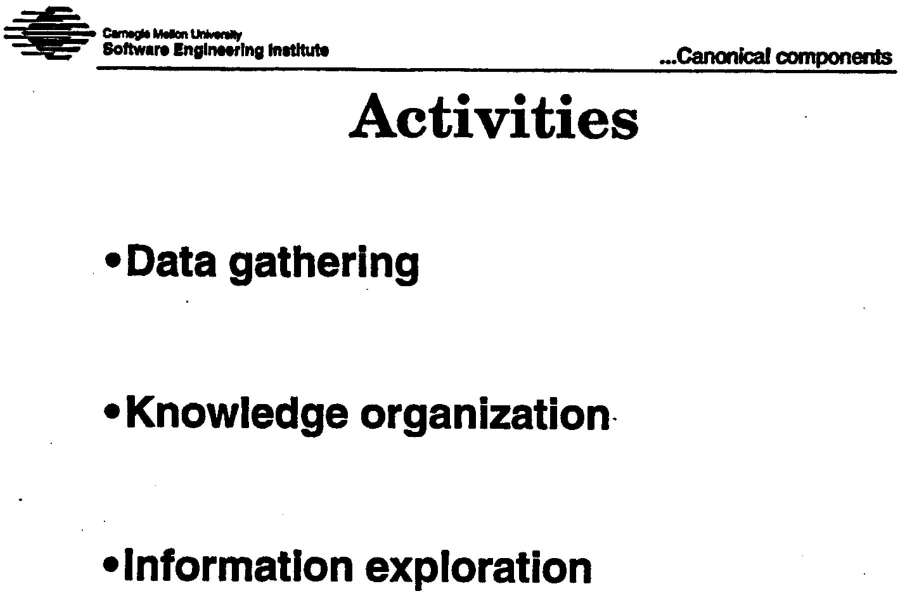
...Canonical components

Artifacts

- Data: Factual information used as basis for study & reasoning
- Knowledge: The sum of what is known or derived
- Information: Selectively communicated knowledge



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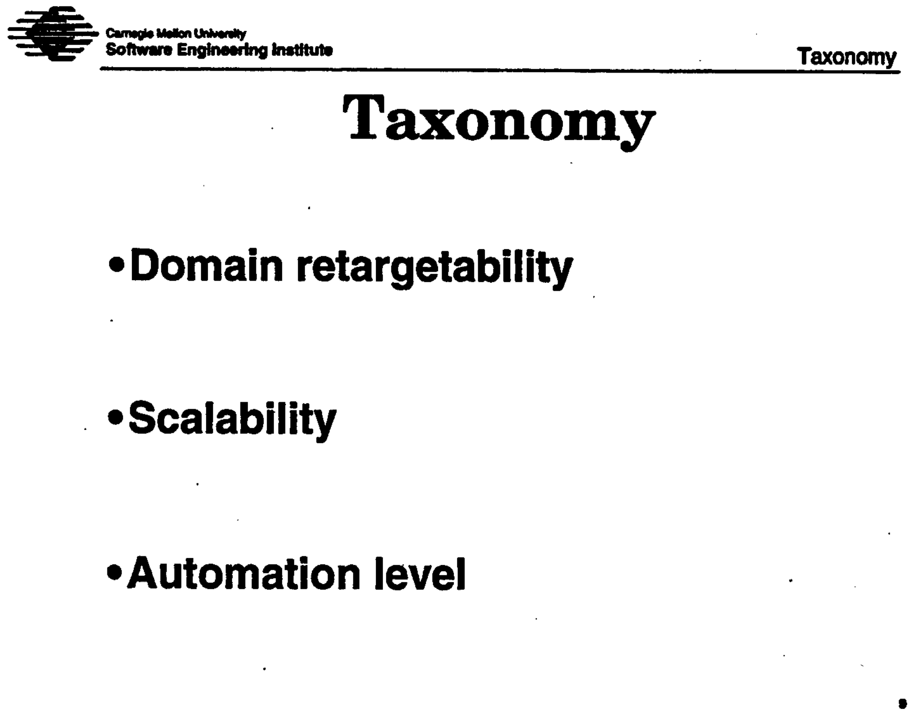
...Canonical components

Activities

- Data gathering
- Knowledge organization
- Information exploration



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Taxonomy

Taxonomy

- Domain retargetability
- Scalability
- Automation level

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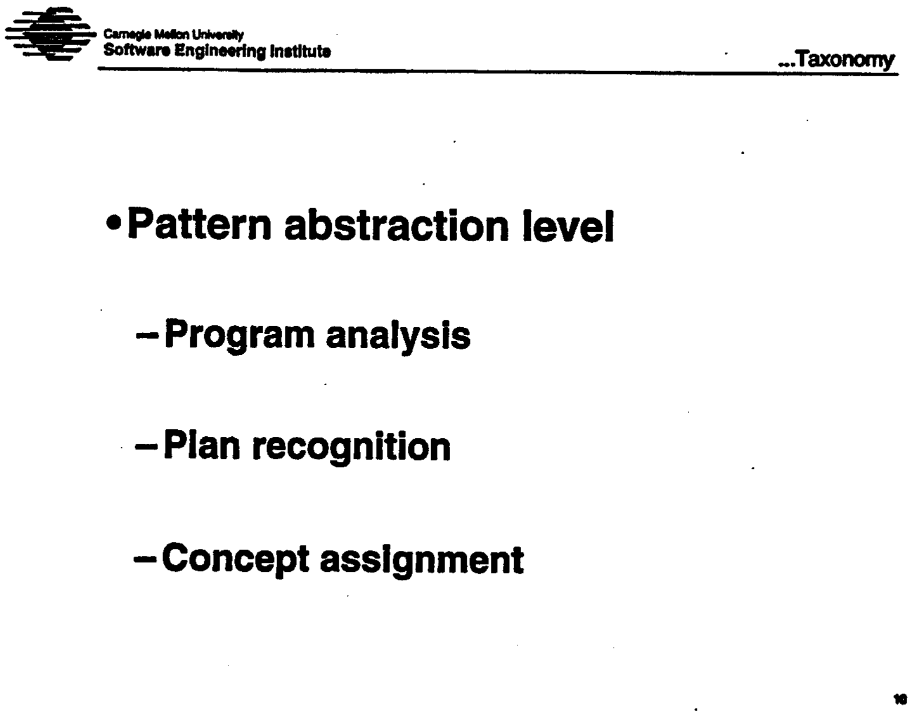

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...Taxonomy

- Pattern abstraction level
  - Program analysis
  - Plan recognition
  - Concept assignment

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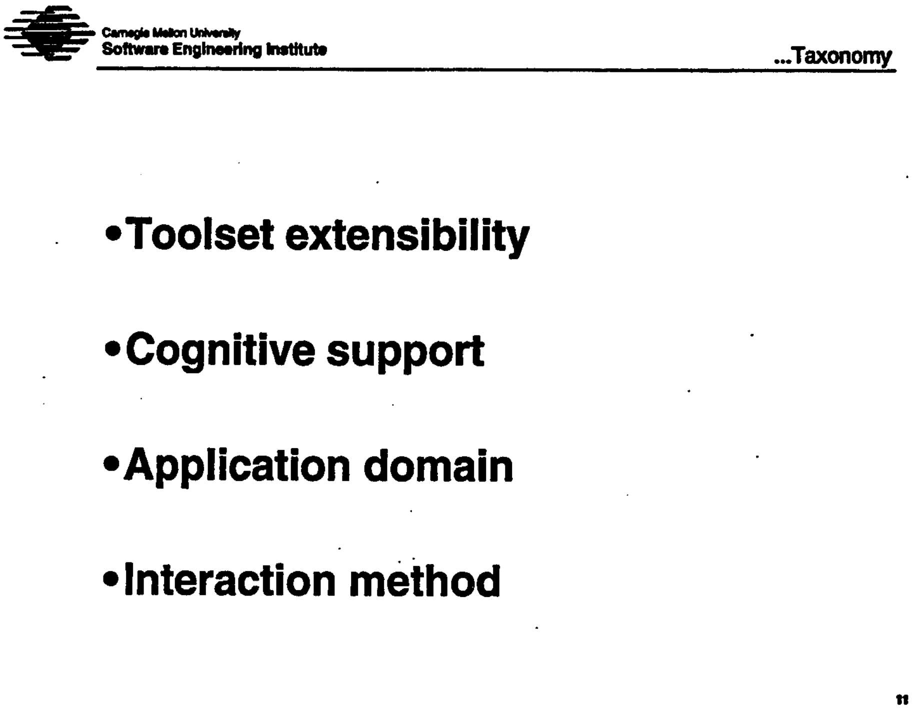

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...Taxonomy

- Toolset extensibility
- Cognitive support
- Application domain
- Interaction method

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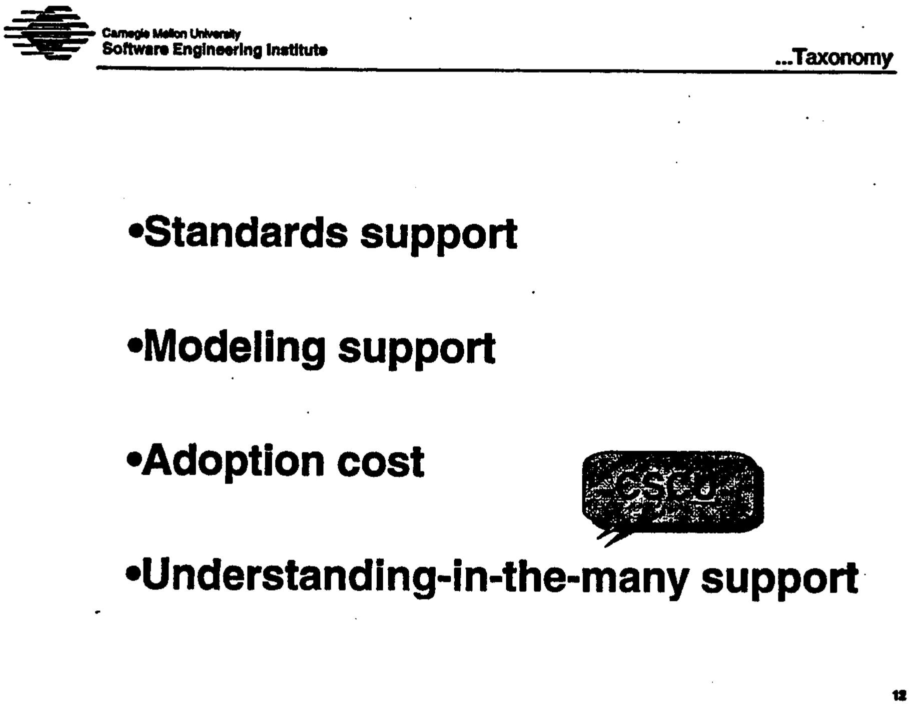

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...Taxonomy

- Standards support
- Modeling support
- Adoption cost
- Understanding-in-the-many support

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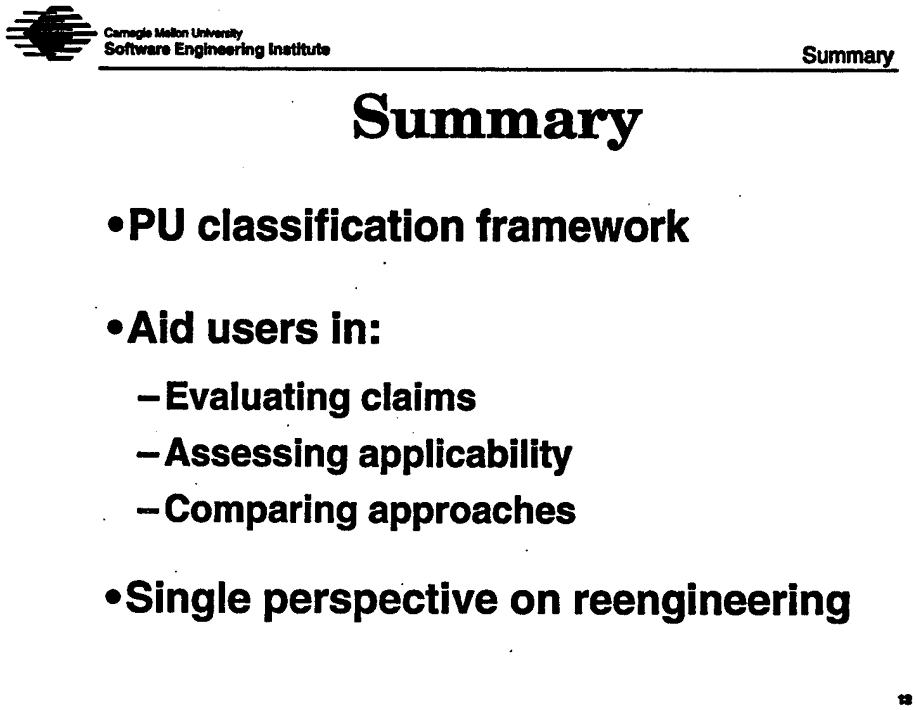

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Summary

Summary

- PU classification framework
- Aid users in:
  - Evaluating claims
  - Assessing applicability
  - Comparing approaches
- Single perspective on reengineering

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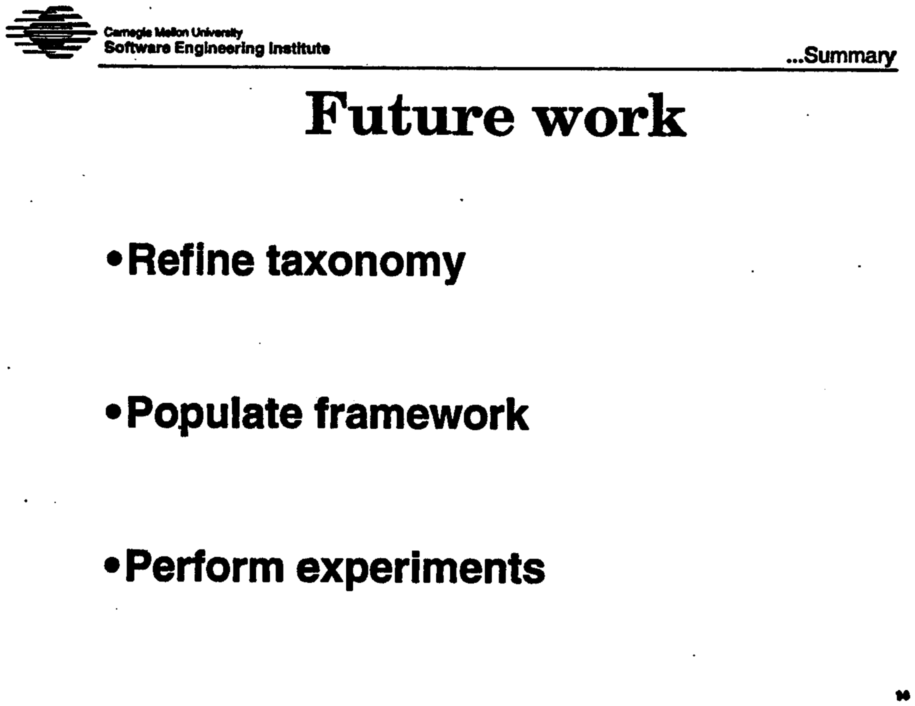

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...Summary

Future work

- Refine taxonomy
- Populate framework
- Perform experiments

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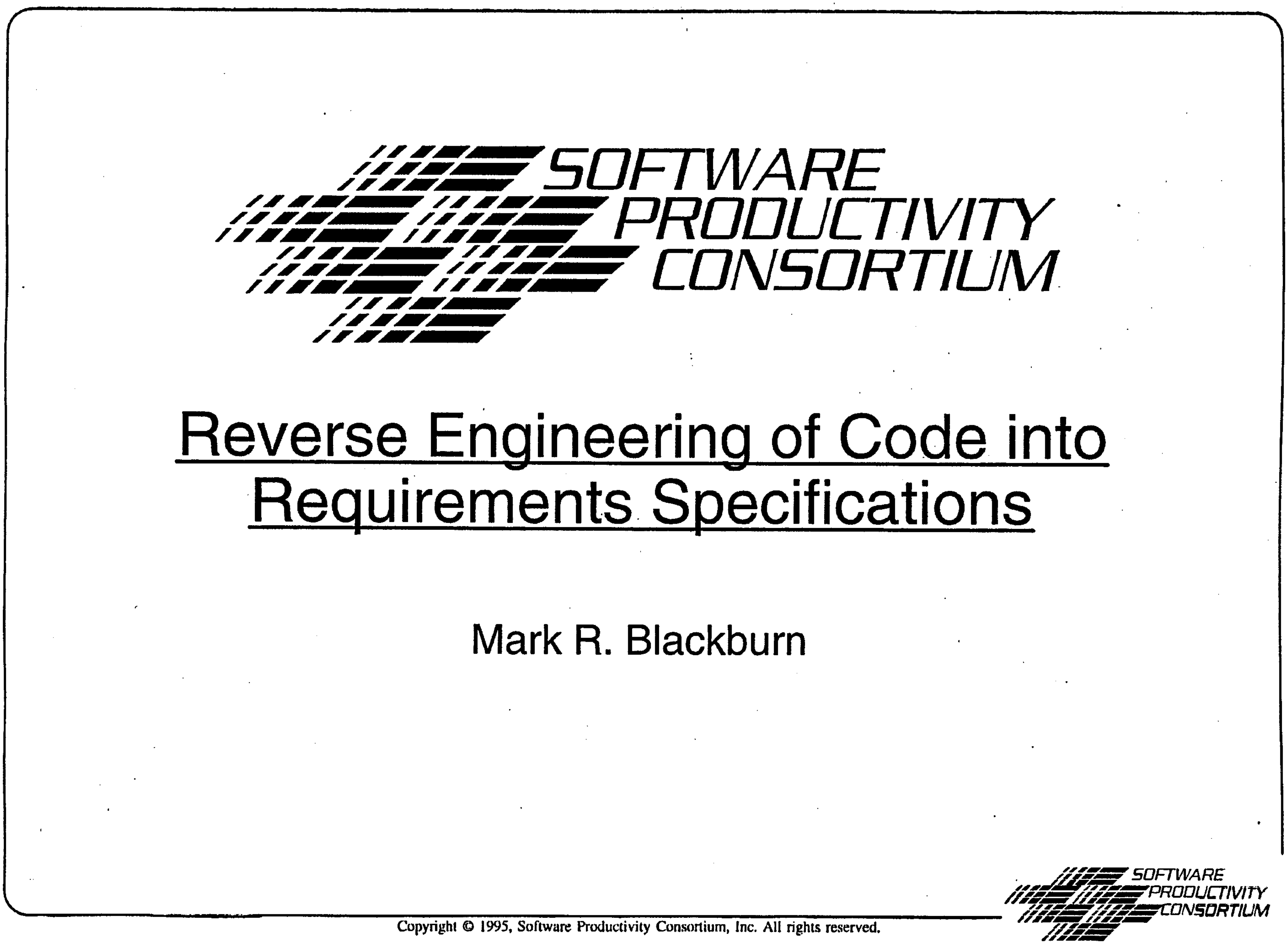
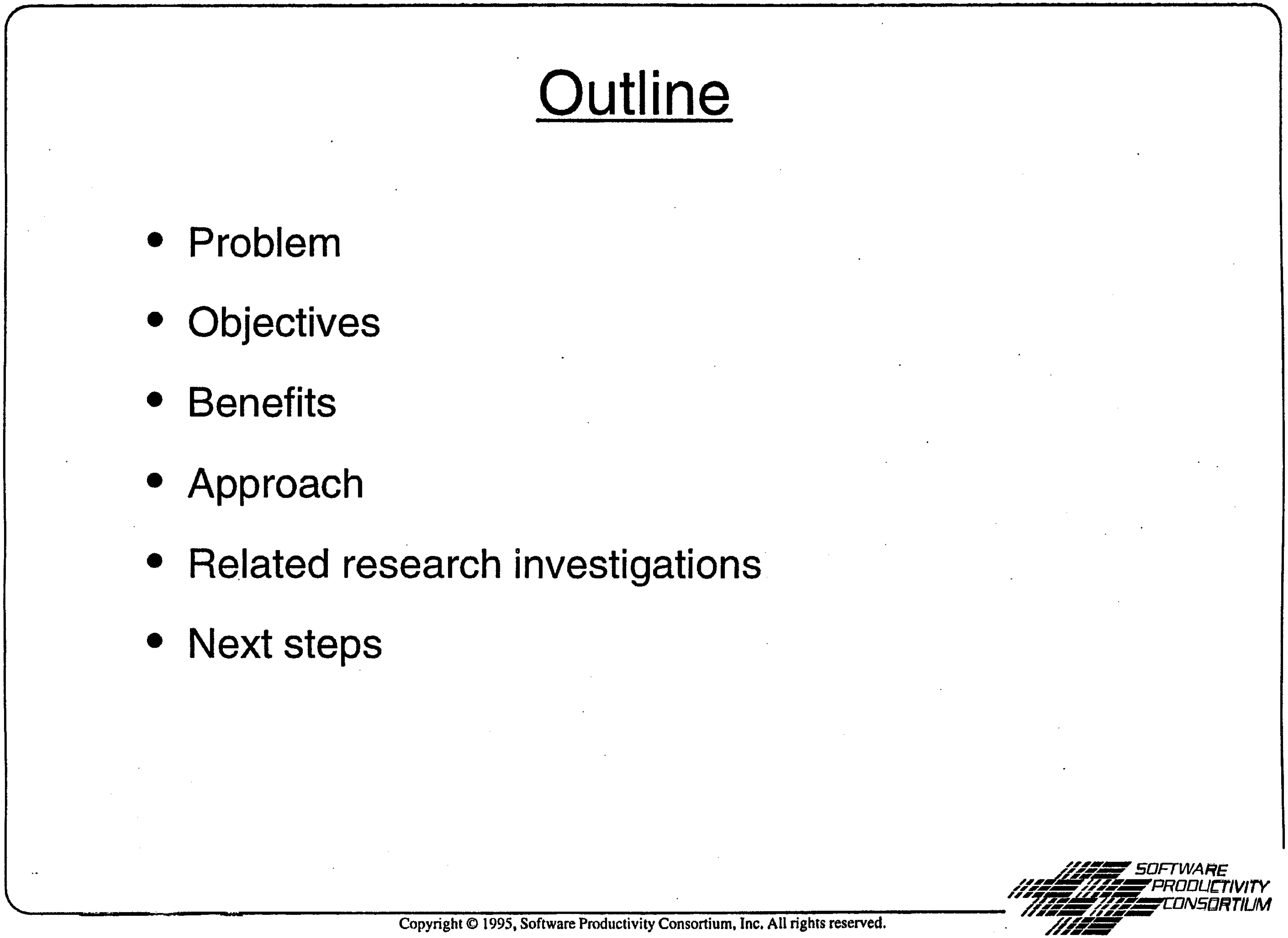


SOFTWARE PRODUCTIVITY CONSORTIUM

Reverse Engineering of Code into Requirements Specifications

Mark R. Blackburn

SOFTWARE PRODUCTIVITY CONSORTIUM



Outline

- Problem
- Objectives
- Benefits
- Approach
- Related research investigations
- Next steps

SOFTWARE PRODUCTIVITY CONSORTIUM

Problem Context

- Testing to support reengineering can account for 50-75% of the cost [Sneed95]
- Common reengineering approach is to:
  - Reengineer legacy into an equivalent system
  - Use legacy system as an oracle for testing the new system
  - Evolve newly reengineered system
- Difficult to develop test sets to ensure that the desired functionality of the legacy exists in new system
- Need basis for developing tests
  - Requirements provide basis, but difficult to extract from legacy

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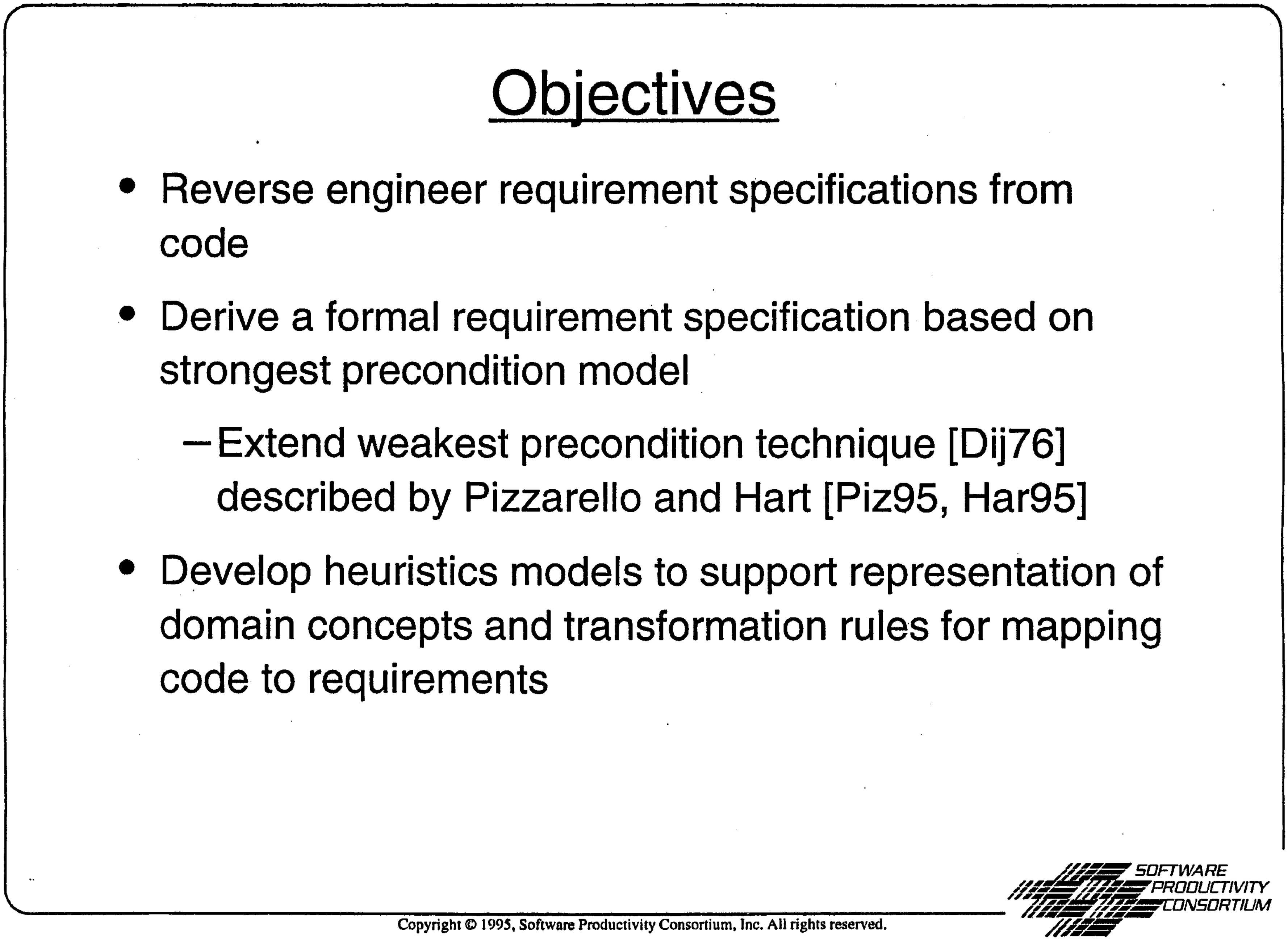

Objectives

- Reverse engineer requirement specifications from code
- Derive a formal requirement specification based on strongest precondition model
  - Extend weakest precondition technique [Dij76] described by Pizzarello and Hart [Piz95, Har95]
- Develop heuristics models to support representation of domain concepts and transformation rules for mapping code to requirements

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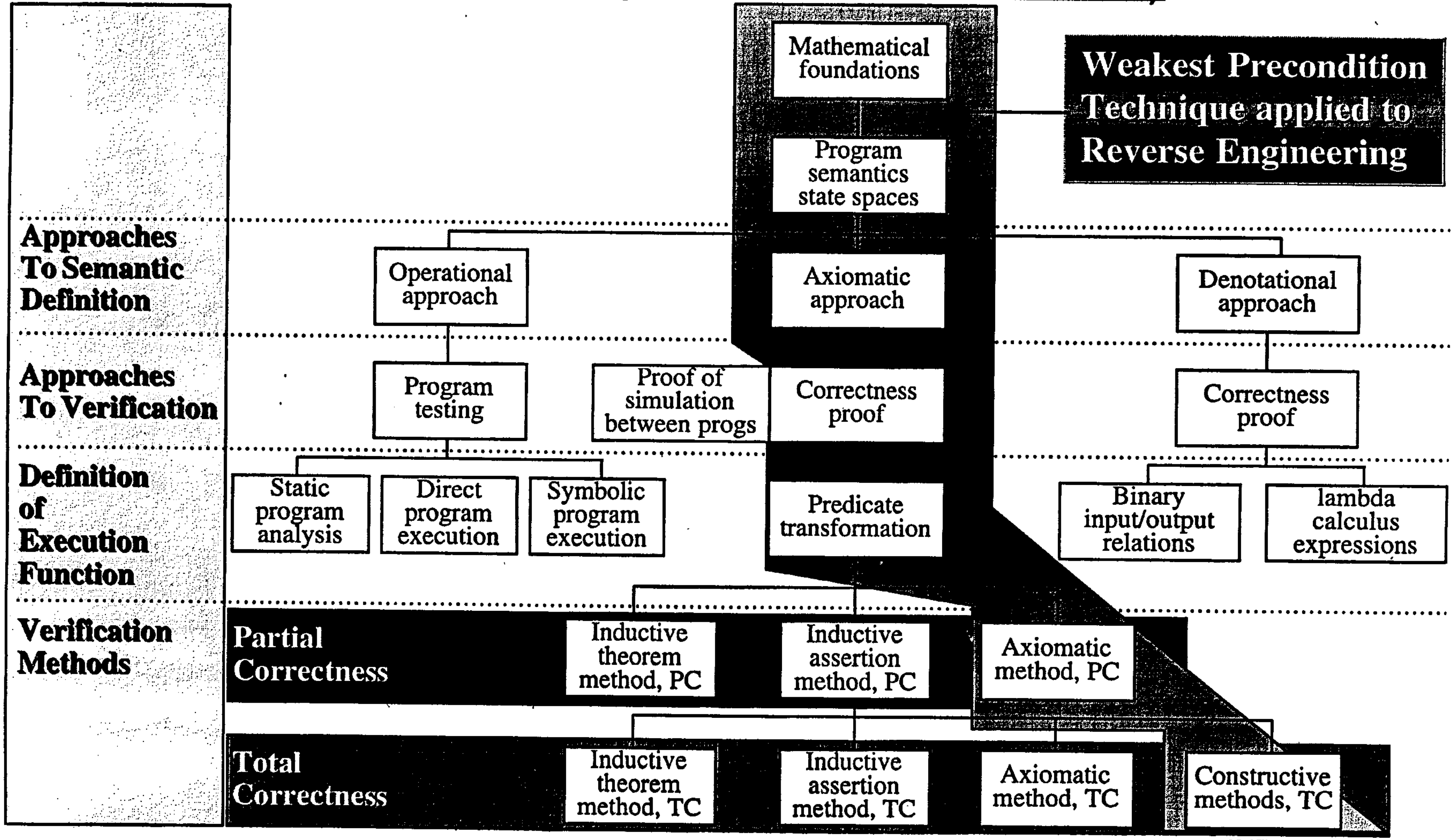
Context: Formal Perspective

(from Taxonomy of Verification Methods)


Mathematical foundations
Program semantics state spaces
Weakest Precondition Technique applied to Reverse Engineering
Approaches To Semantic Definition
Operational approach
Axiomatic approach
Denotational approach
Approaches To Verification
Program testing
Proof of simulation between progs
Correctness proof
Correctness proof
Definition of Execution Function
Static program analysis
Direct program execution
Symbolic program execution
Predicate transformation
Binary input/output relations
lambda calculus expressions
Verification Methods
Partial Correctness
Inductive theorem method, PC
Inductive assertion method, PC
Axiomatic method, PC
Total Correctness
Inductive theorem method, TC
Inductive assertion method, TC
Axiomatic method, TC
Constructive methods, TC

Berg et. al.1982

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Benefits

- Requirements could be used to automatically generate test cases to assess the reengineered system
- Requirements would support the transformation, and evolution of the reengineered system
- Concept can be applied to other problems
  - –Development of high assurance software [NISTa]

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Related Research Investigations

- Most reverse engineering approaches use analysis techniques derived from **operational approach**
- Reverse transformational approach based on **denotational approach** to characterization of program [War93]
- Constructive method associated with **axiomatic approach**
  - UNITY at UT Austin
  - Peritus Software using UNITY
- Reverse engineering using heuristic models based on domain analysis
  - Representation is key
  - Need inferencing capabilities integrated with model representation
  - Need pattern matching to search for abstract constructs

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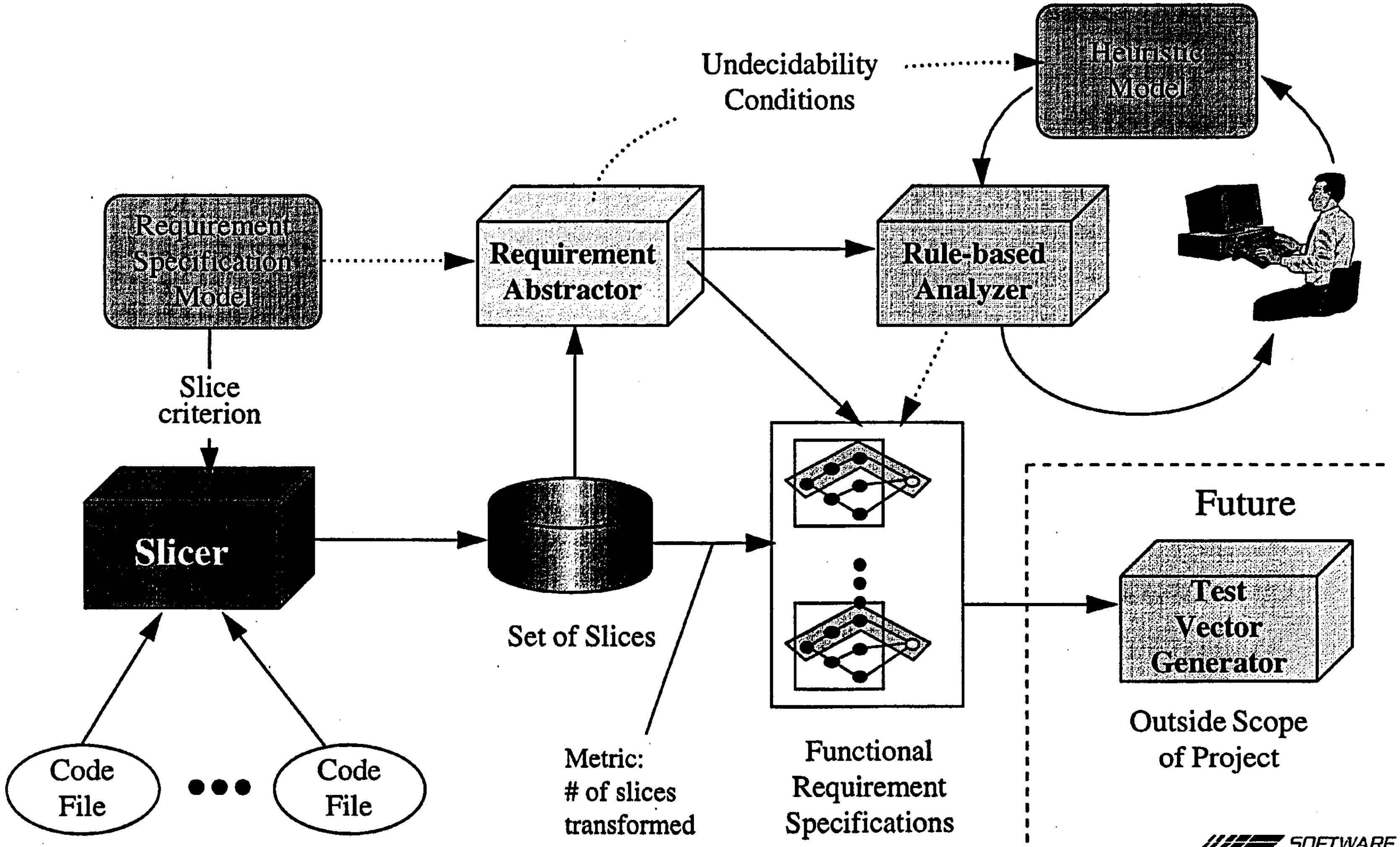
Approach Framework



Requirement Specification Model

Slice criterion

Slicer

Code File

Code File

Set of Slices

Requirement Abstractor

Undecidability Conditions

Heuristic Model

Rule-based Analyzer

Metric: # of slices transformed

Functional Requirement Specifications

Future

Test Vector Generator

Outside Scope of Project

SOFTWARE PRODUCTIVITY CONSORTIUM

Next Steps

- Use SNAP for rule-based analyzer
  - Allows domain concepts to be represented in an object model
- Provides two unique attributes for modeling heuristics
  - Supports inference rules as part of object model
  - Supports pattern/language analysis and representation
- Inference rules are used in the transformation process
- Patterns/language supports recognition of language relationships that can be abstracted together or away

SOFTWARE
PRODUCTIVITY
CONSORTIUM

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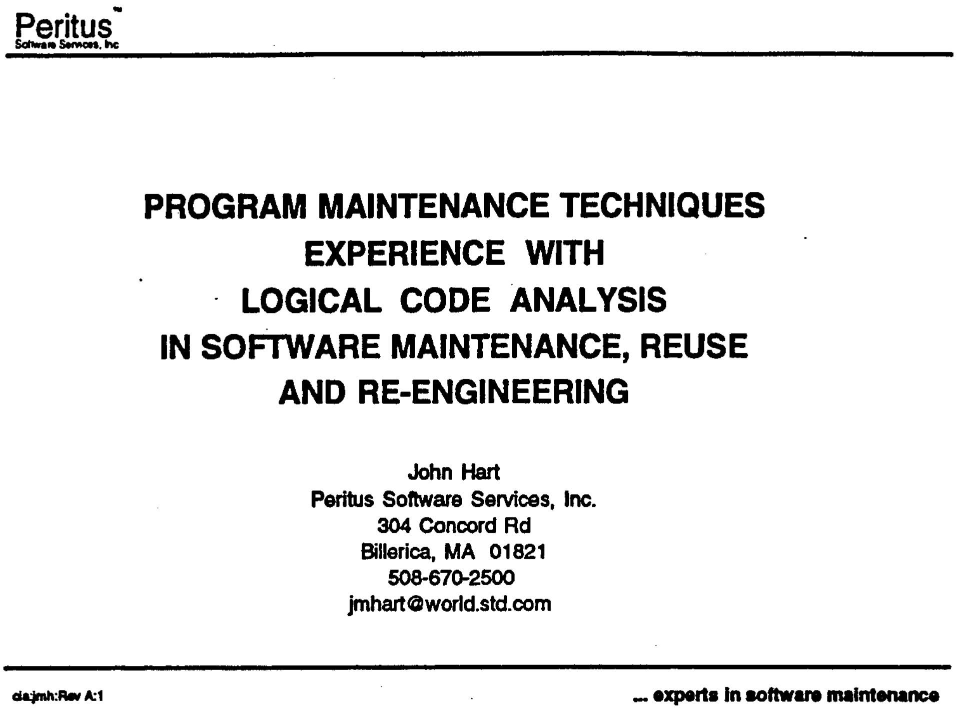

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PROGRAM MAINTENANCE TECHNIQUES EXPERIENCE WITH LOGICAL CODE ANALYSIS IN SOFTWARE MAINTENANCE, REUSE AND RE-ENGINEERING

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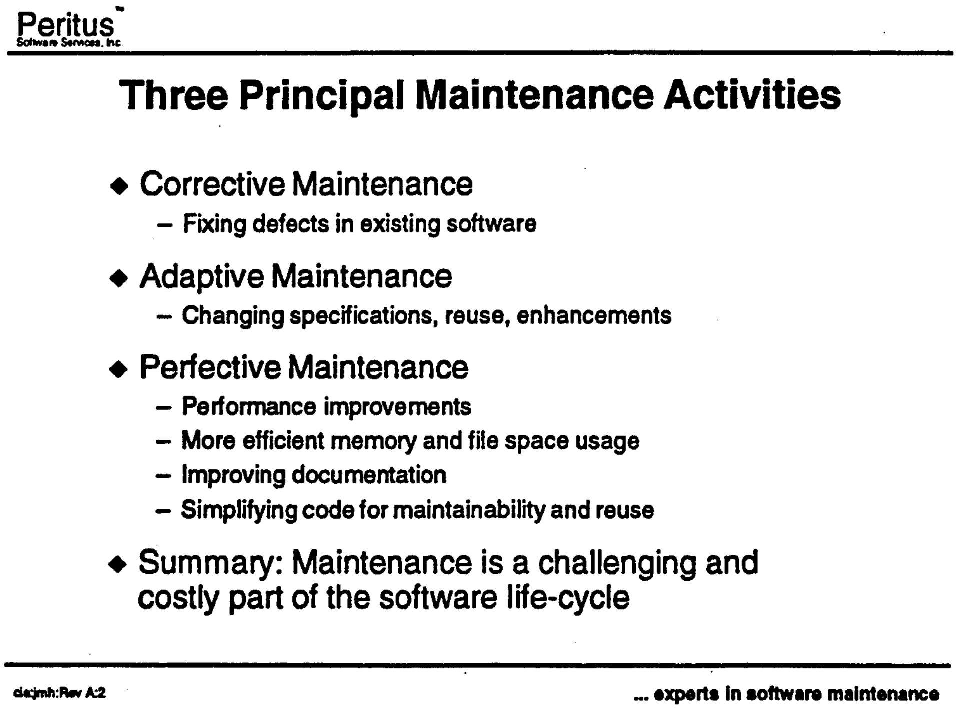
da:jmh:Rev A:1

... experts in software maintenance



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Three Principal Maintenance Activities

- Corrective Maintenance
  - Fixing defects in existing software
- Adaptive Maintenance
  - Changing specifications, reuse, enhancements
- Perfective Maintenance
  - Performance improvements
  - More efficient memory and file space usage
  - Improving documentation
  - Simplifying code for maintainability and reuse
- Summary: Maintenance is a challenging and costly part of the software life-cycle

da:jmh:Rev A:2

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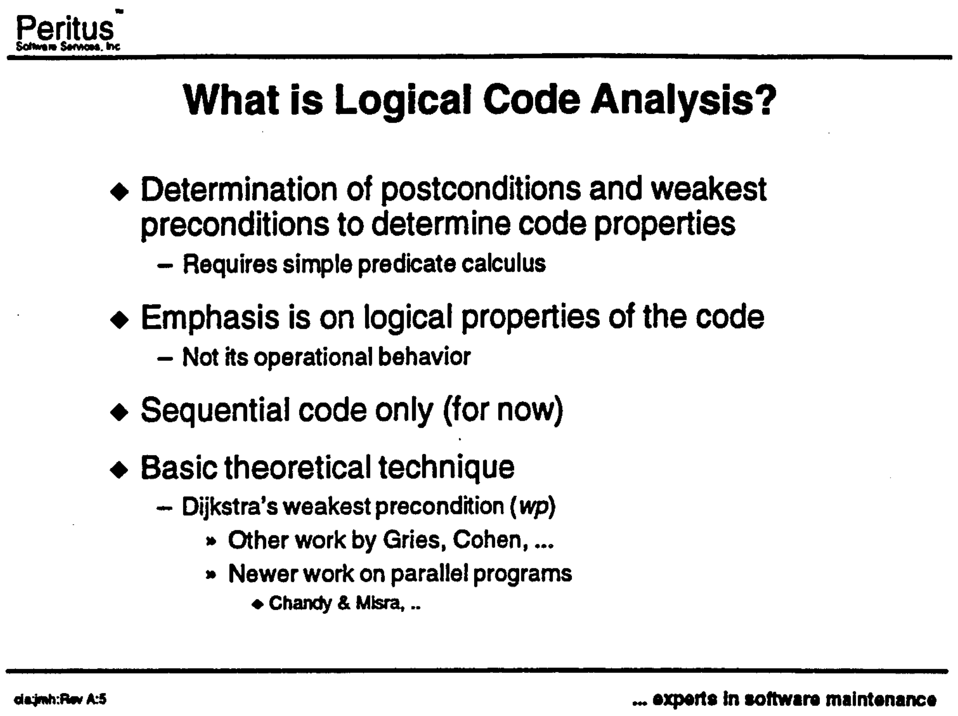

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What is Logical Code Analysis?

- Determination of postconditions and weakest preconditions to determine code properties
  - Requires simple predicate calculus
- Emphasis is on logical properties of the code
  - Not its operational behavior
- Sequential code only (for now)
- Basic theoretical technique
  - Dijkstra's weakest precondition (*wp*)
    - Other work by Gries, Cohen, ...
    - Newer work on parallel programs
      - Chandy & Misra, ..

da:jmh:Rev A:5

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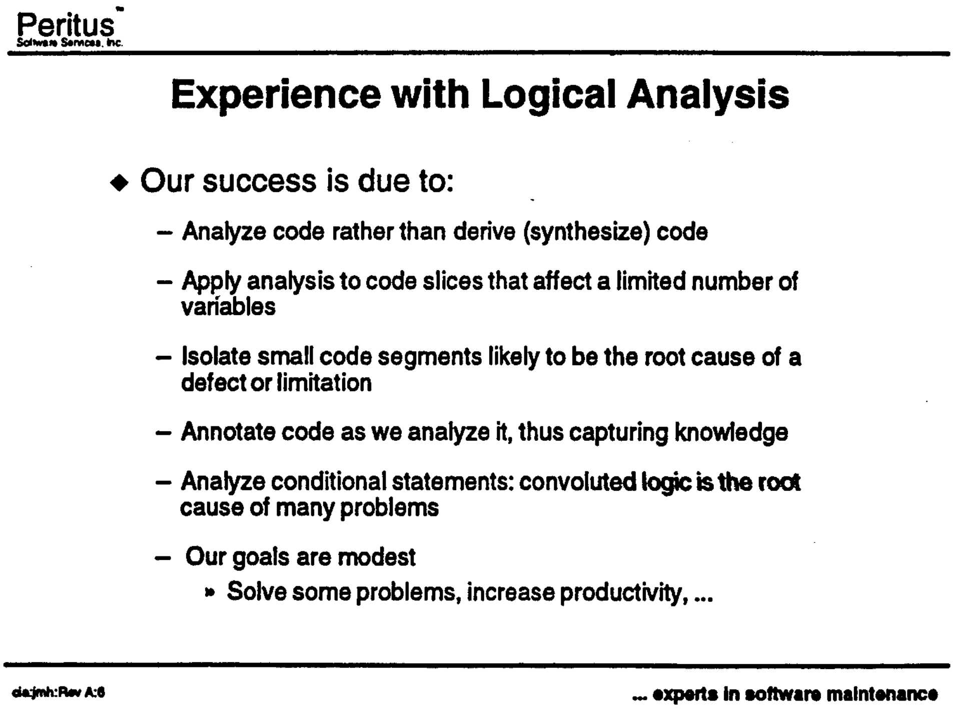

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Experience with Logical Analysis

- Our success is due to:
  - Analyze code rather than derive (synthesize) code
  - Apply analysis to code slices that affect a limited number of variables
  - Isolate small code segments likely to be the root cause of a defect or limitation
  - Annotate code as we analyze it, thus capturing knowledge
  - Analyze conditional statements: convoluted logic is the root cause of many problems
  - Our goals are modest
    - Solve some problems, increase productivity, ...

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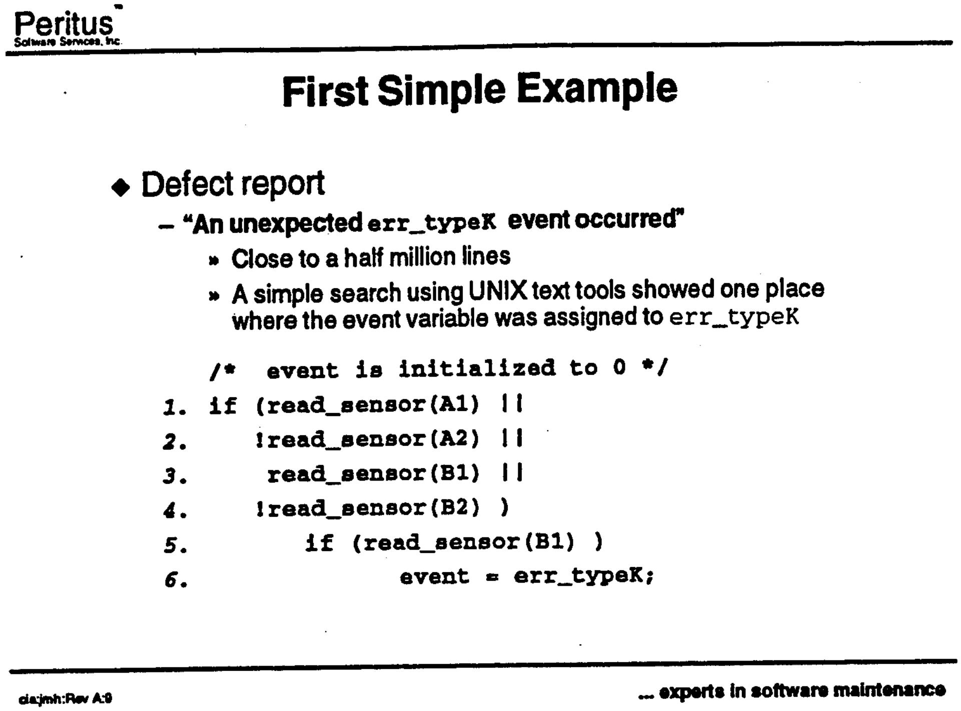

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First Simple Example

- Defect report
  - "An unexpected `err_typeK` event occurred"
    - » Close to a half million lines
    - » A simple search using UNIX text tools showed one place where the event variable was assigned to `err_typeK`

```
/*  event is initialized to 0 */
if (read_sensor(A1) ||
    !read_sensor(A2) ||
     read_sensor(B1) ||
    !read_sensor(B2) )
        if (read_sensor(B1) )
                event = err_typeK;
```

dajmh:Rev A:9

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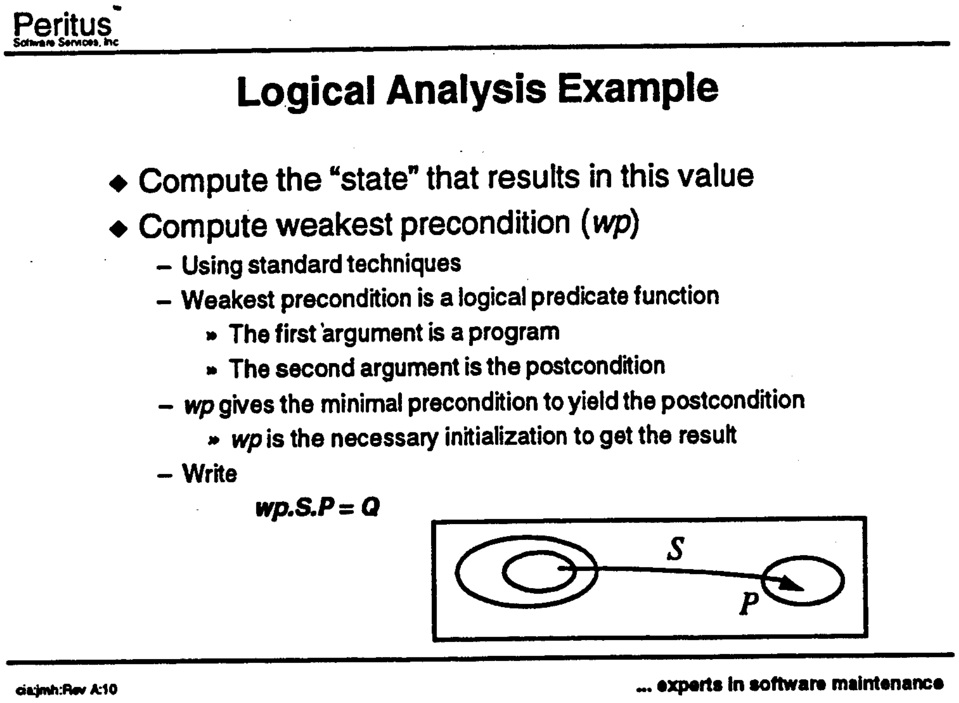

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Logical Analysis Example

- Compute the "state" that results in this value
- Compute weakest precondition (*wp*)
  - Using standard techniques
  - Weakest precondition is a logical predicate function
    - » The first argument is a program
    - » The second argument is the postcondition
  - *wp* gives the minimal precondition to yield the postcondition
    - » *wp* is the necessary initialization to get the result
  - Write

wp.S.P = Q

dajmh:Rev A:10

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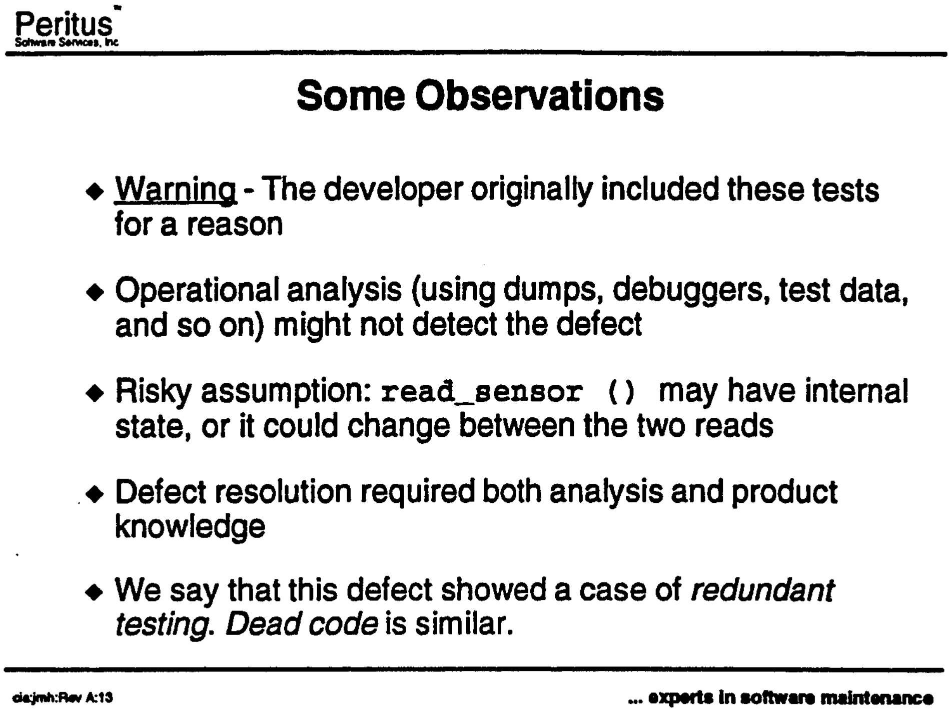

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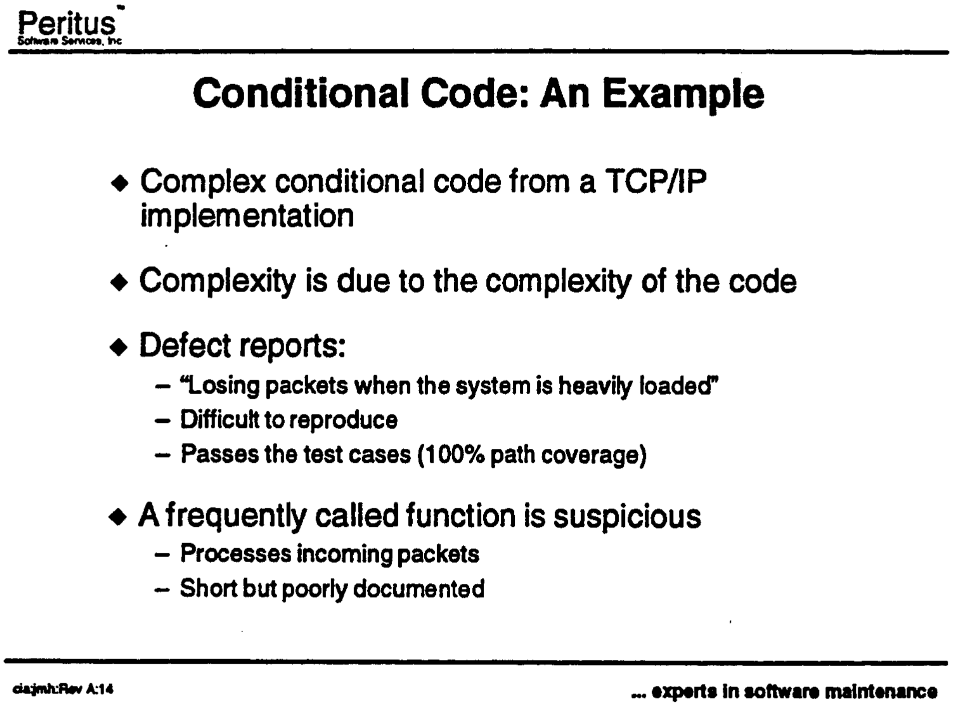
Some Observations

- Warning - The developer originally included these tests for a reason
- Operational analysis (using dumps, debuggers, test data, and so on) might not detect the defect
- Risky assumption: `read_sensor ()` may have internal state, or it could change between the two reads
- Defect resolution required both analysis and product knowledge
- We say that this defect showed a case of *redundant testing*. *Dead code* is similar.

dia:jmh:Rev A:13 **... experts in software maintenance**



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Conditional Code: An Example

- Complex conditional code from a TCP/IP implementation
- Complexity is due to the complexity of the code
- Defect reports:
  - "Losing packets when the system is heavily loaded"
  - Difficult to reproduce
  - Passes the test cases (100% path coverage)
- A frequently called function is suspicious
  - Processes incoming packets
  - Short but poorly documented

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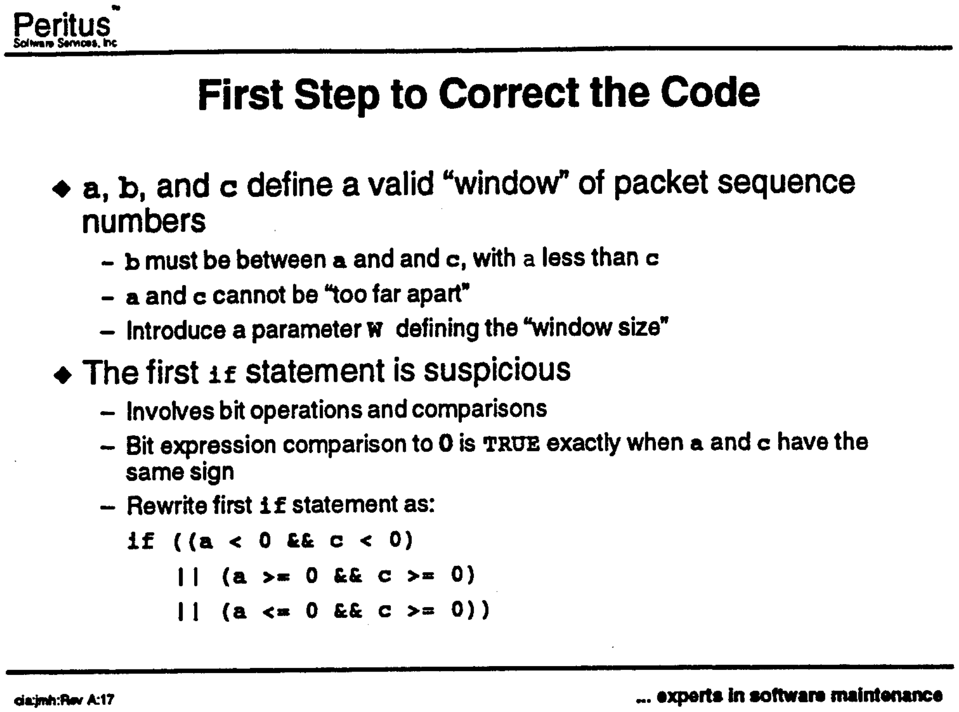

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First Step to Correct the Code

- a, b, and c define a valid "window" of packet sequence numbers
  - b must be between a and and c, with a less than c
  - a and c cannot be "too far apart"
  - Introduce a parameter W defining the "window size"
- The first if statement is suspicious
  - Involves bit operations and comparisons
  - Bit expression comparison to 0 is TRUE exactly when a and c have the same sign
  - Rewrite first if statement as:

```
if ((a < 0 && c < 0)
    || (a >= 0 && c >= 0)
    || (a <= 0 && c >= 0))
```

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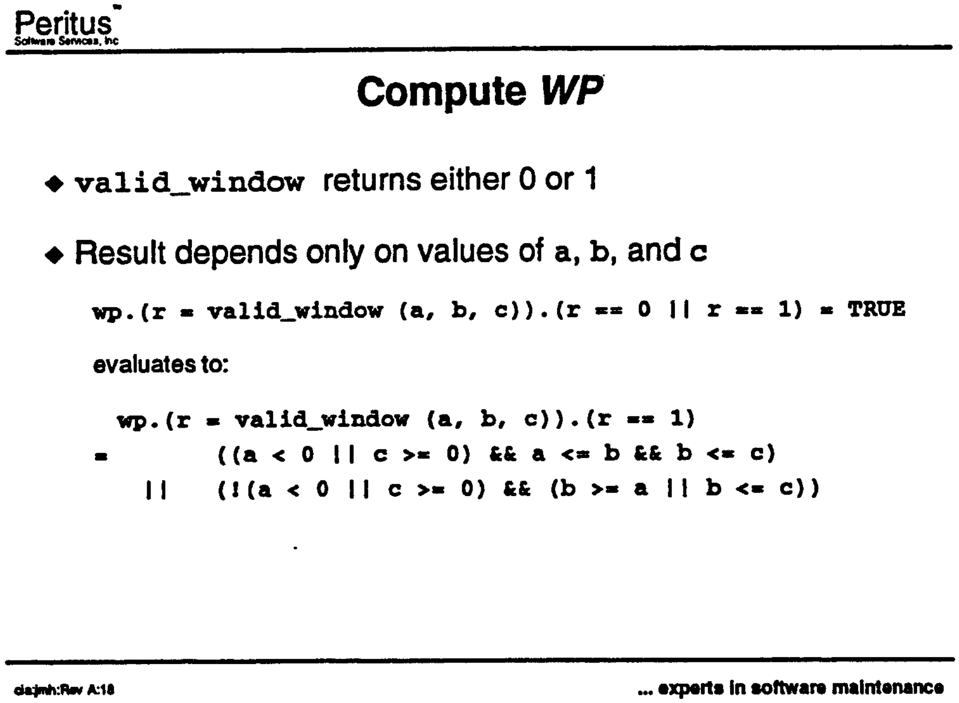

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Compute *WP*

- valid_window returns either 0 or 1
- Result depends only on values of a, b, and c

```
wp.(r = valid_window (a, b, c)).(r == 0 || r == 1) = TRUE
```

evaluates to:

```
  wp.(r = valid_window (a, b, c)).(r == 1)
=        ((a < 0 || c >= 0) && a <= b && b <= c)
   ||    (!(a < 0 || c >= 0) && (b >= a || b <= c))
```

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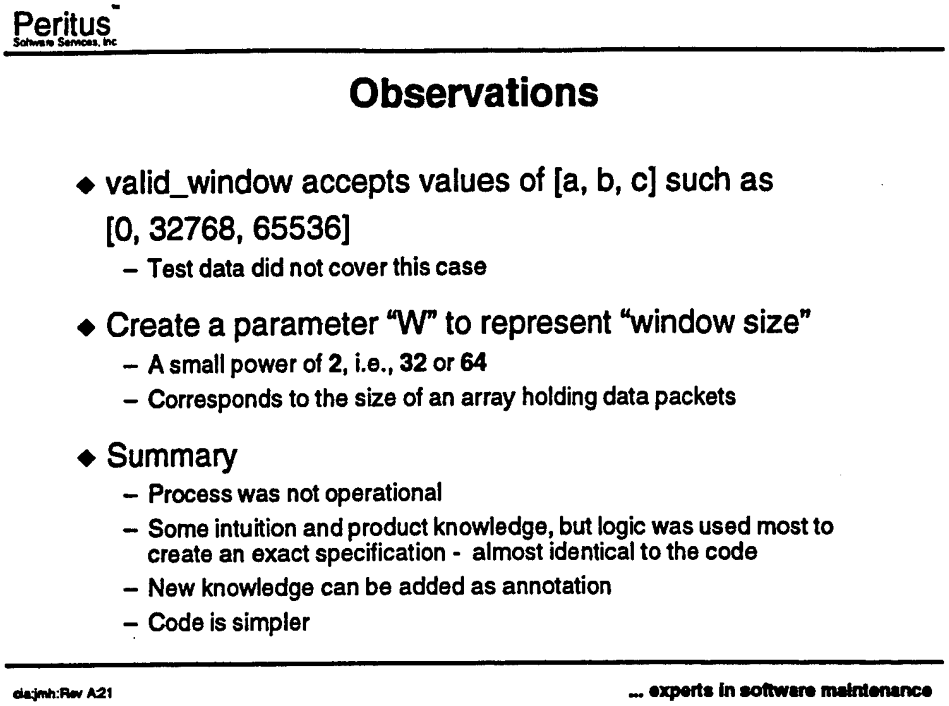

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Observations

- valid_window accepts values of [a, b, c] such as [0, 32768, 65536]
  - Test data did not cover this case
- Create a parameter "W" to represent "window size"
  - A small power of 2, i.e., 32 or 64
  - Corresponds to the size of an array holding data packets
- Summary
  - Process was not operational
  - Some intuition and product knowledge, but logic was used most to create an exact specification - almost identical to the code
  - New knowledge can be added as annotation
  - Code is simpler

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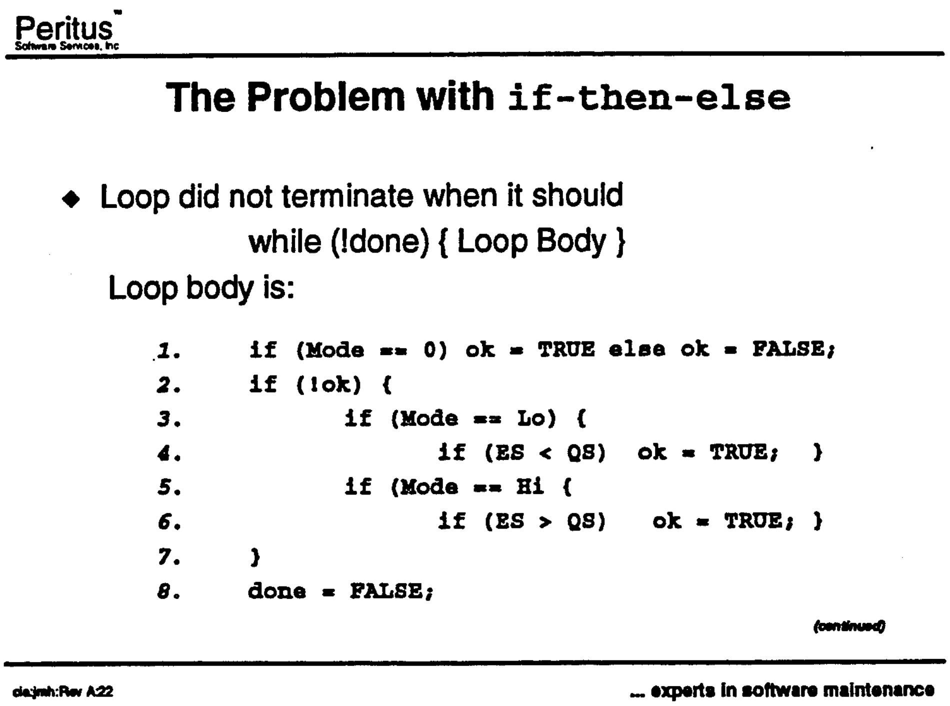

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The Problem with `if-then-else`

- Loop did not terminate when it should

  while (!done) { Loop Body }

  Loop body is:

```
if (Mode == 0) ok = TRUE else ok = FALSE;
if (!ok) {
        if (Mode == Lo) {
                if (ES < QS)  ok = TRUE;  }
        if (Mode == Hi {
                if (ES > QS)   ok = TRUE; }
}
done = FALSE;
```

(continued)

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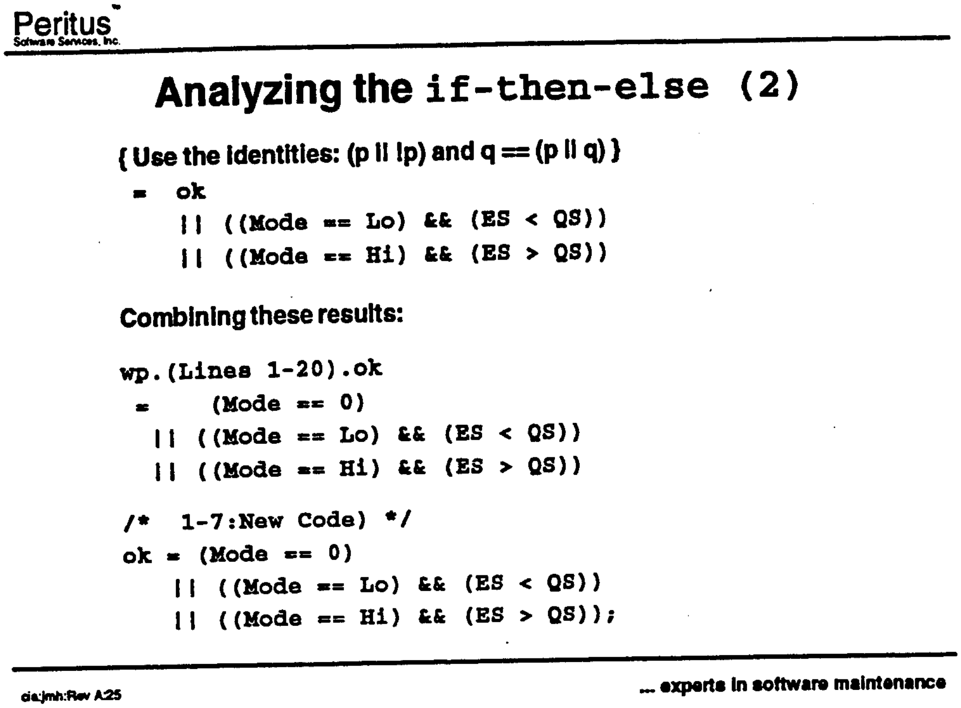

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Analyzing the `if-then-else` (2)

{ Use the identities: (p || !p) and q == (p || q) }

```
 =  ok
    || ((Mode == Lo) && (ES < QS))
    || ((Mode == Hi) && (ES > QS))
```

Combining these results:

```
wp.(Lines 1-20).ok
 =     (Mode == 0)
  || ((Mode == Lo) && (ES < QS))
  || ((Mode == Hi) && (ES > QS))

/*  1-7:New Code) */
ok = (Mode == 0)
    || ((Mode == Lo) && (ES < QS))
    || ((Mode == Hi) && (ES > QS));
```

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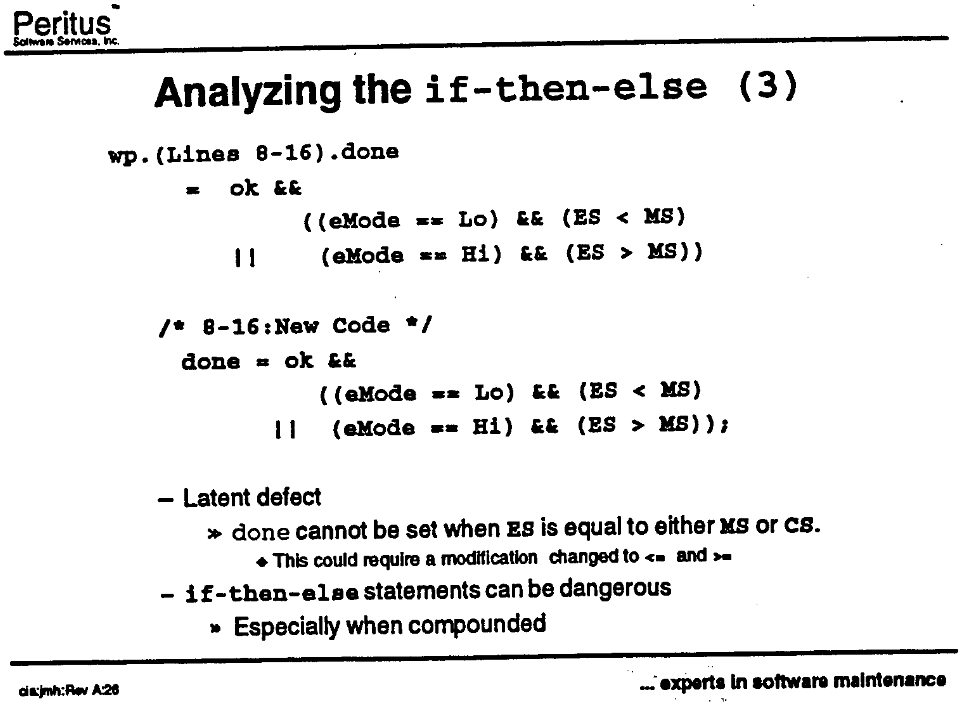

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Analyzing the `if-then-else` (3)

```
wp.(Lines 8-16).done
    =  ok &&
           ((eMode == Lo) && (ES < MS)
       ||    (eMode == Hi) && (ES > MS))

   /* 8-16:New Code */
    done = ok &&
            ((eMode == Lo) && (ES < MS)
          ||  (eMode == Hi) && (ES > MS));
```

- Latent defect
  - » done cannot be set when `ES` is equal to either `MS` or `CS`.
    - ◆ This could require a modification changed to `<=` and `>=`
- `if-then-else` statements can be dangerous
  - » Especially when compounded

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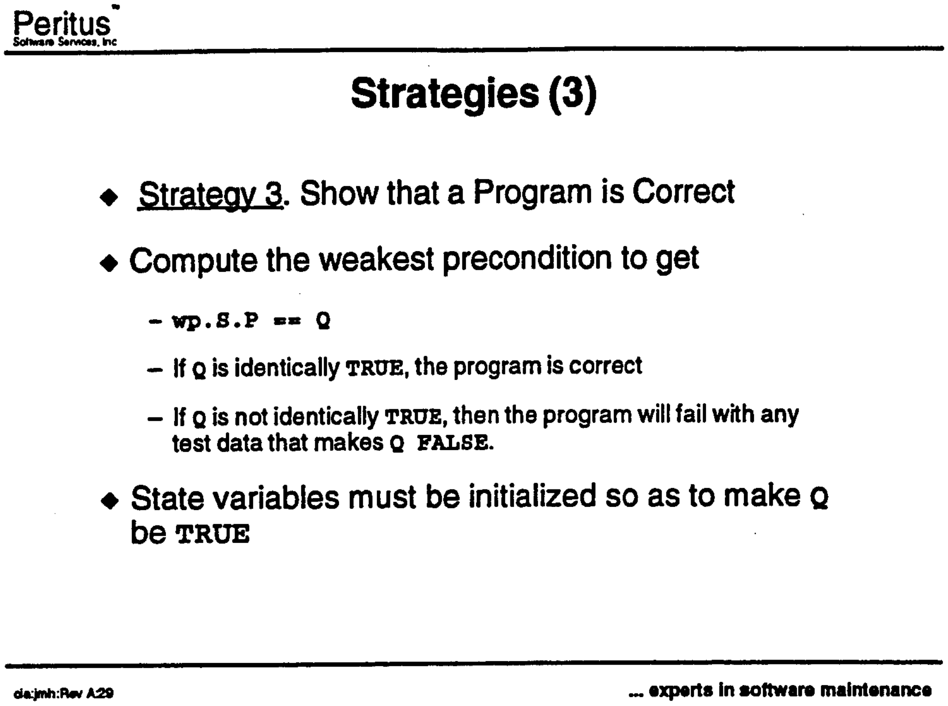

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Strategies (3)

- Strategy 3. Show that a Program is Correct
- Compute the weakest precondition to get
  - `wp.S.P == Q`
  - If Q is identically TRUE, the program is correct
  - If Q is not identically TRUE, then the program will fail with any test data that makes Q FALSE.
- State variables must be initialized so as to make Q be TRUE

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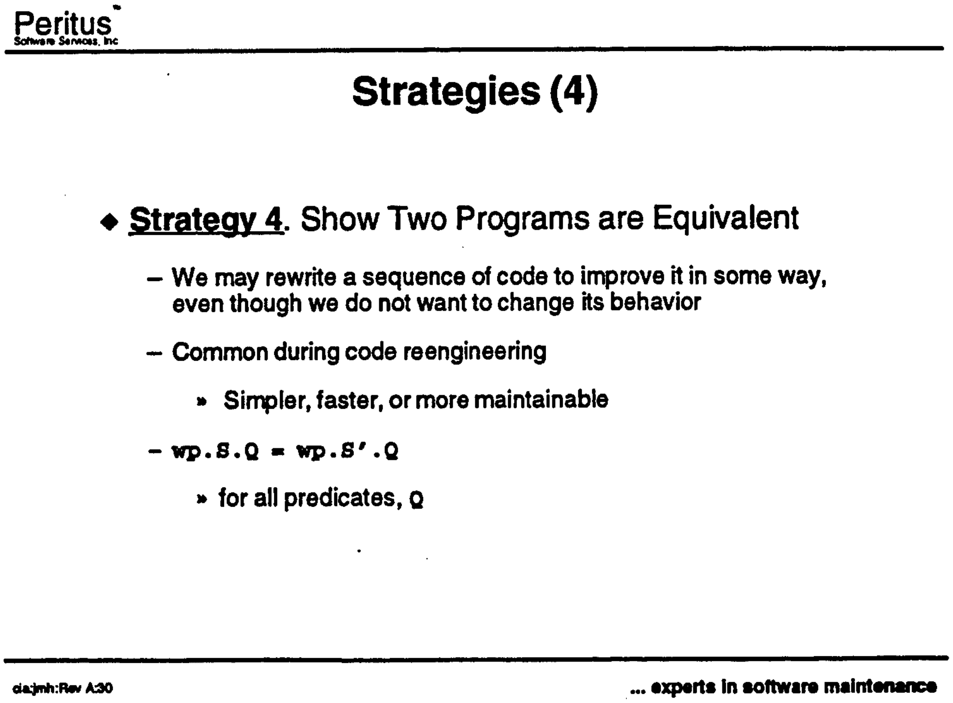

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Strategies (4)

- Strategy 4. Show Two Programs are Equivalent
  - We may rewrite a sequence of code to improve it in some way, even though we do not want to change its behavior
  - Common during code reengineering
    - » Simpler, faster, or more maintainable
  - `wp.S.Q = wp.S'.Q`
    - » for all predicates, Q

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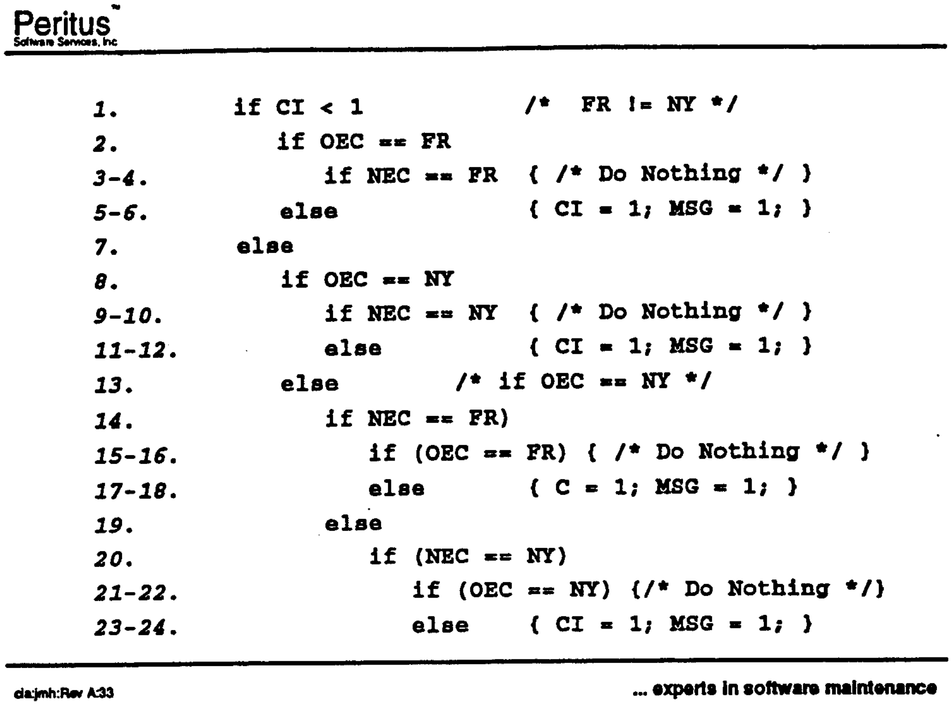

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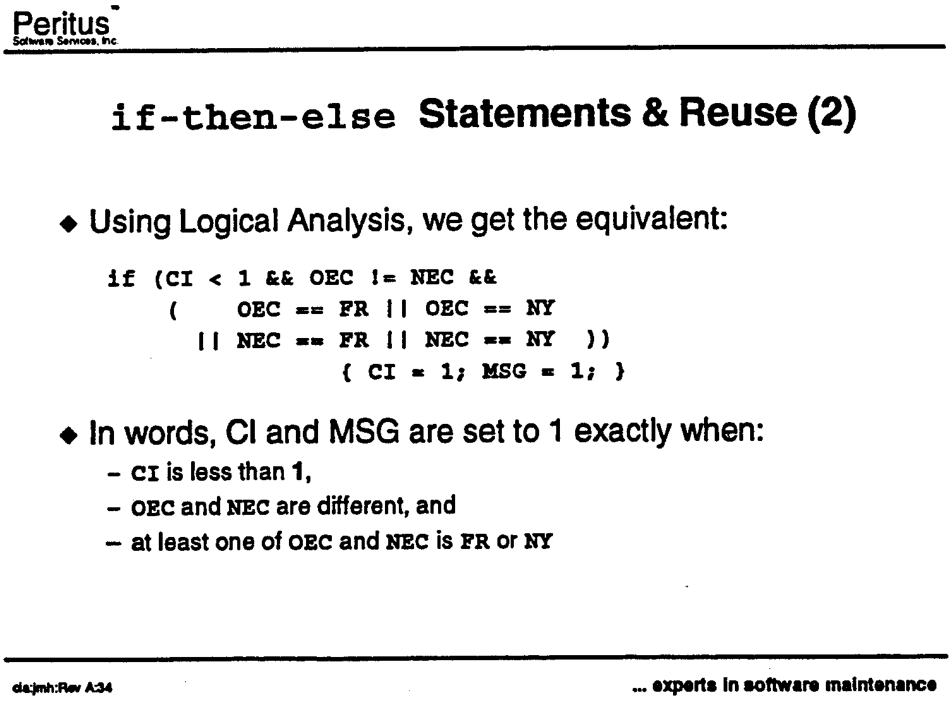
```
1.          if CI < 1            /*  FR != NY */
2.             if OEC == FR
3-4.              if NEC == FR   { /* Do Nothing */ }
5-6.           else              { CI = 1; MSG = 1; }
7.          else
8.             if OEC == NY
9-10.             if NEC == NY   { /* Do Nothing */ }
11-12.            else           { CI = 1; MSG = 1; }
13.            else         /* if OEC == NY */
14.               if NEC == FR)
15-16.               if (OEC == FR) { /* Do Nothing */ }
17-18.               else        { C = 1; MSG = 1; }
19.               else
20.                  if (NEC == NY)
21-22.                  if (OEC == NY) {/* Do Nothing */}
23-24.                  else    { CI = 1; MSG = 1; }
```

da:jmh:Rev A:33 ... experts in software maintenance



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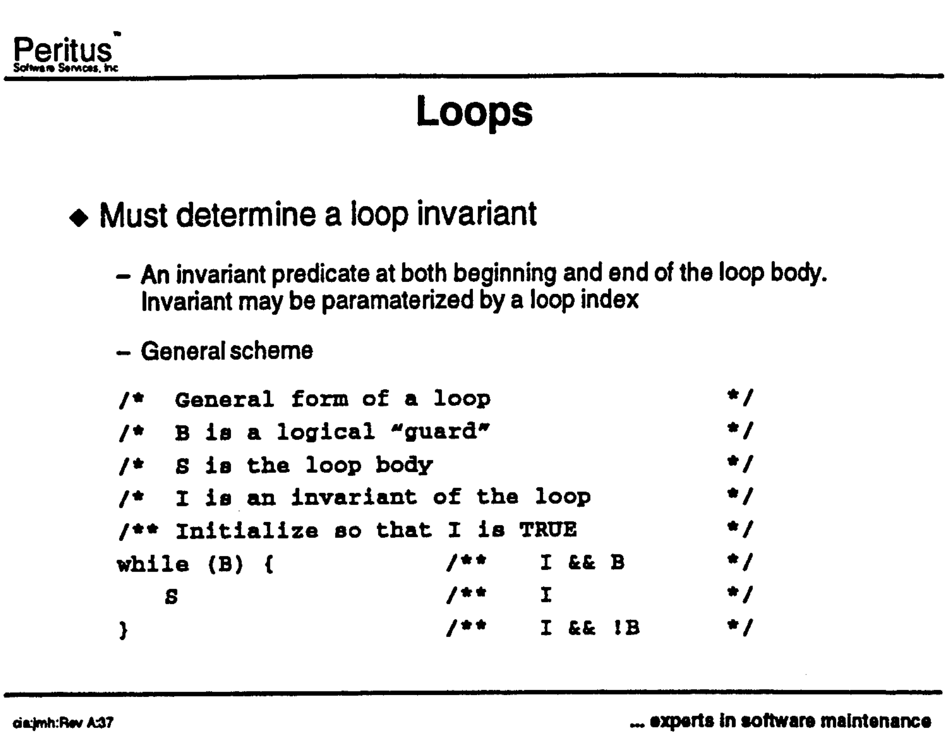
`if-then-else` Statements & Reuse (2)

- Using Logical Analysis, we get the equivalent:

```
if (CI < 1 && OEC != NEC &&
    (     OEC == FR || OEC == NY
       || NEC == FR || NEC == NY   ))
                { CI = 1; MSG = 1; }
```

- In words, CI and MSG are set to 1 exactly when:
  - `CI` is less than **1**,
  - `OEC` and `NEC` are different, and
  - at least one of `OEC` and `NEC` is `FR` or `NY`

da:jmh:Rev A:34 ... experts in software maintenance



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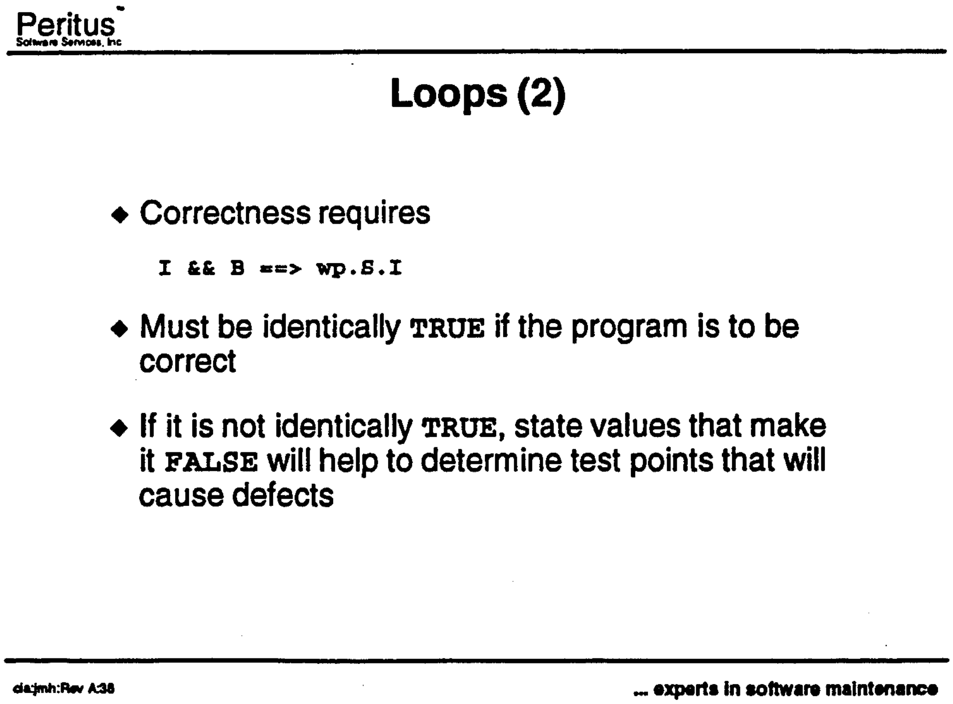
Loops

- Must determine a loop invariant
  - An invariant predicate at both beginning and end of the loop body. Invariant may be paramaterized by a loop index
  - General scheme

```
/*   General form of a loop                           */
/*   B is a logical "guard"                           */
/*   S is the loop body                               */
/*   I is an invariant of the loop                    */
/**  Initialize so that I is TRUE                     */
while (B) {             /**    I && B                 */
    S                   /**    I                      */
}                       /**    I && !B                */
```

da:jmh:Rev A:37 ... experts in software maintenance



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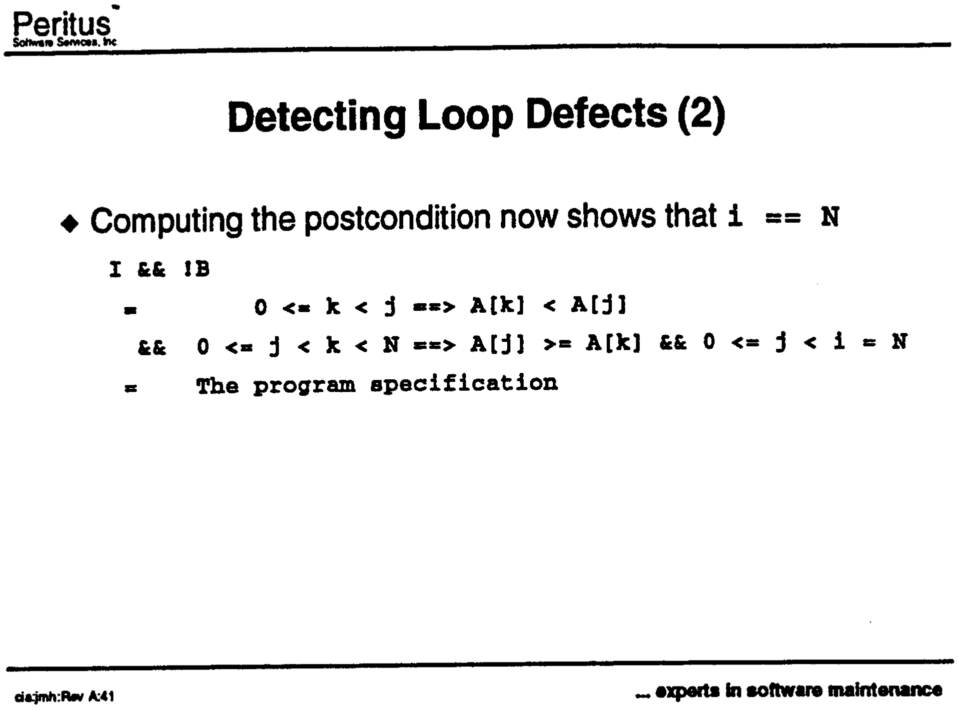
Loops (2)

- Correctness requires

```
I && B ==> wp.S.I
```

- Must be identically `TRUE` if the program is to be correct
- If it is not identically `TRUE`, state values that make it `FALSE` will help to determine test points that will cause defects

da:jmh:Rev A:38 ... experts in software maintenance



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Detecting Loop Defects (2)

- Computing the postcondition now shows that `i == N`

```
I && !B
 =        0 <= k < j ==> A[k] < A[j]
  &&  0 <= j < k < N ==> A[j] >= A[k] && 0 <= j < i = N
 =    The program specification
```

dajmh:Rev A:41

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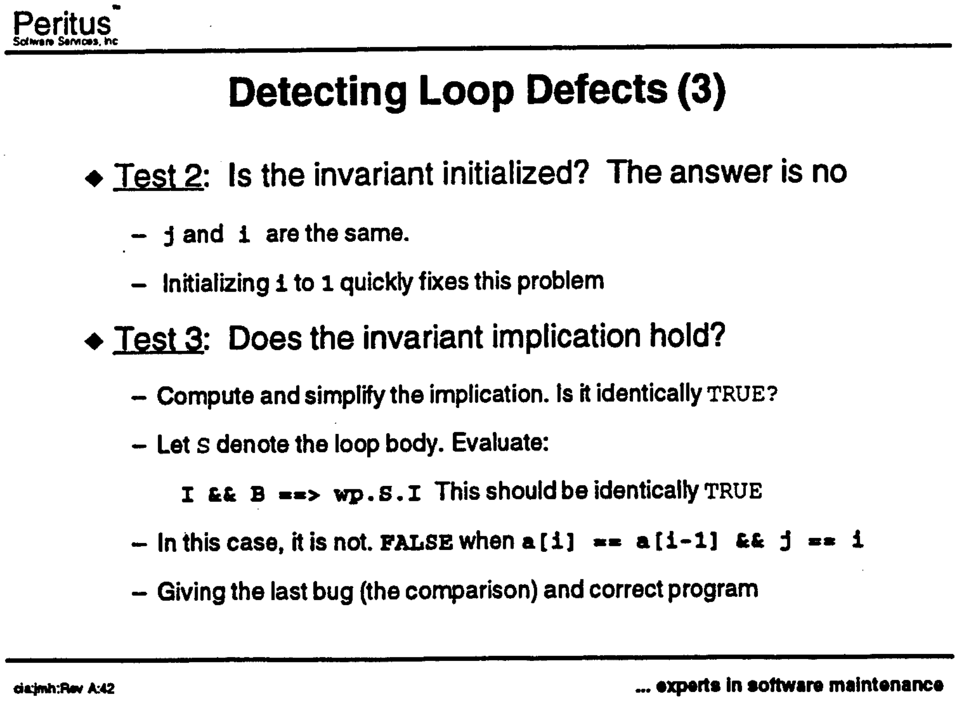

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Detecting Loop Defects (3)

- Test 2: Is the invariant initialized? The answer is no
  - `j` and `i` are the same.
  - Initializing `i` to `1` quickly fixes this problem
- Test 3: Does the invariant implication hold?
  - Compute and simplify the implication. Is it identically `TRUE`?
  - Let `S` denote the loop body. Evaluate:

    `I && B ==> wp.S.I` This should be identically `TRUE`
  - In this case, it is not. `FALSE` when `a[i] == a[i-1] && j == i`
  - Giving the last bug (the comparison) and correct program

dajmh:Rev A:42

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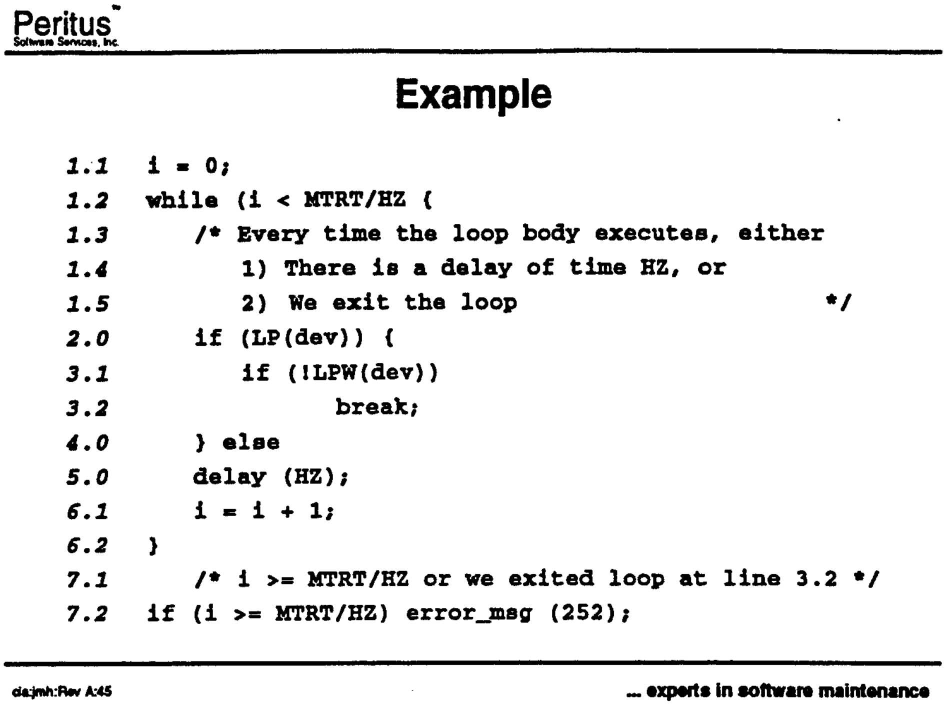

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Example

```
1.1  i = 0;
1.2  while (i < MTRT/HZ {
1.3     /* Every time the loop body executes, either
1.4        1) There is a delay of time HZ, or
1.5        2) We exit the loop                      */
2.0     if (LP(dev)) {
3.1        if (!LPW(dev))
3.2              break;
4.0     } else
5.0     delay (HZ);
6.1     i = i + 1;
6.2  }
7.1     /* i >= MTRT/HZ or we exited loop at line 3.2 */
7.2  if (i >= MTRT/HZ) error_msg (252);
```

da:jmh:Rev A:45

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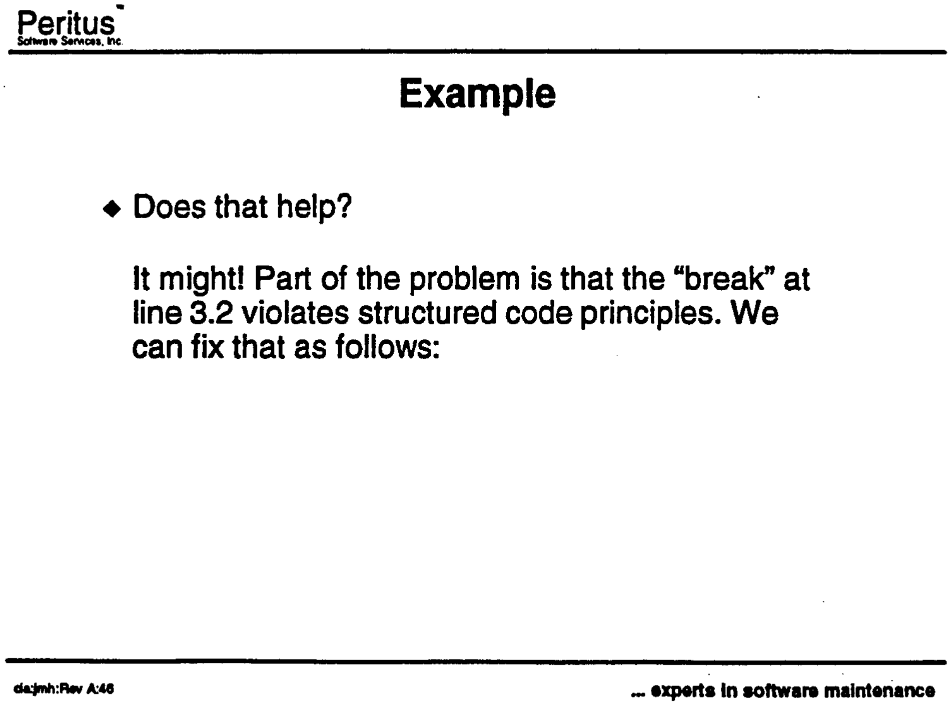

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Example

- ◆ Does that help?

  It might! Part of the problem is that the "break" at line 3.2 violates structured code principles. We can fix that as follows:

da:jmh:Rev A:46

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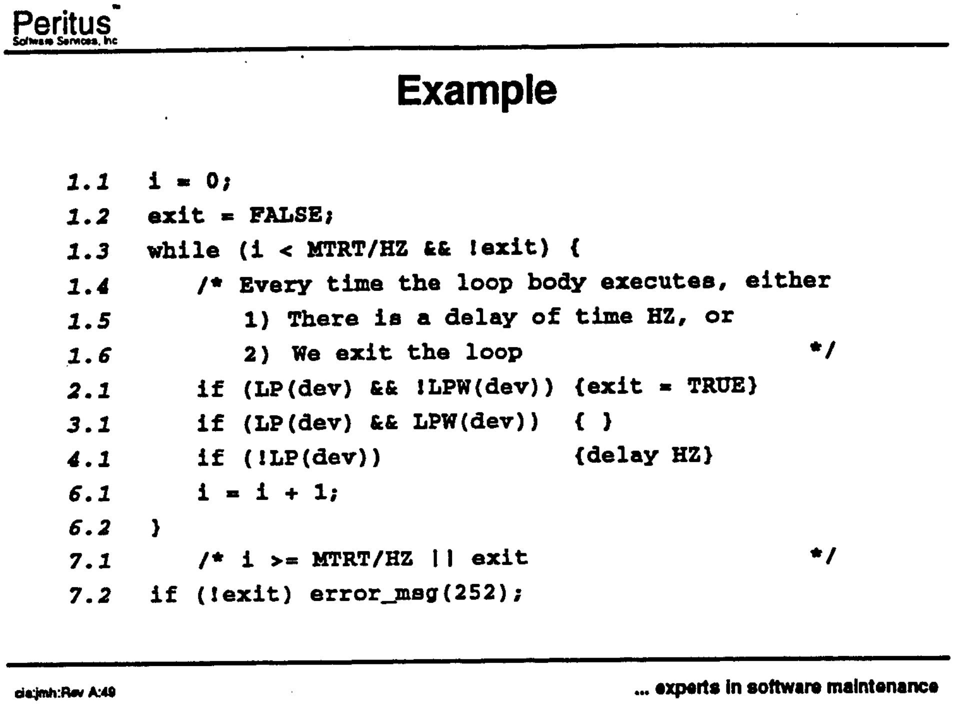

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Example

```
1.1  i = 0;
1.2  exit = FALSE;
1.3  while (i < MTRT/HZ && !exit) {
1.4     /* Every time the loop body executes, either
1.5        1) There is a delay of time HZ, or
1.6        2) We exit the loop                        */
2.1     if (LP(dev) && !LPW(dev)) {exit = TRUE}
3.1     if (LP(dev) && LPW(dev))  { }
4.1     if (!LP(dev))             {delay HZ}
6.1     i = i + 1;
6.2  }
7.1     /* i >= MTRT/HZ || exit                       */
7.2  if (!exit) error_msg(252);
```

cia:jmh:Rev A:49

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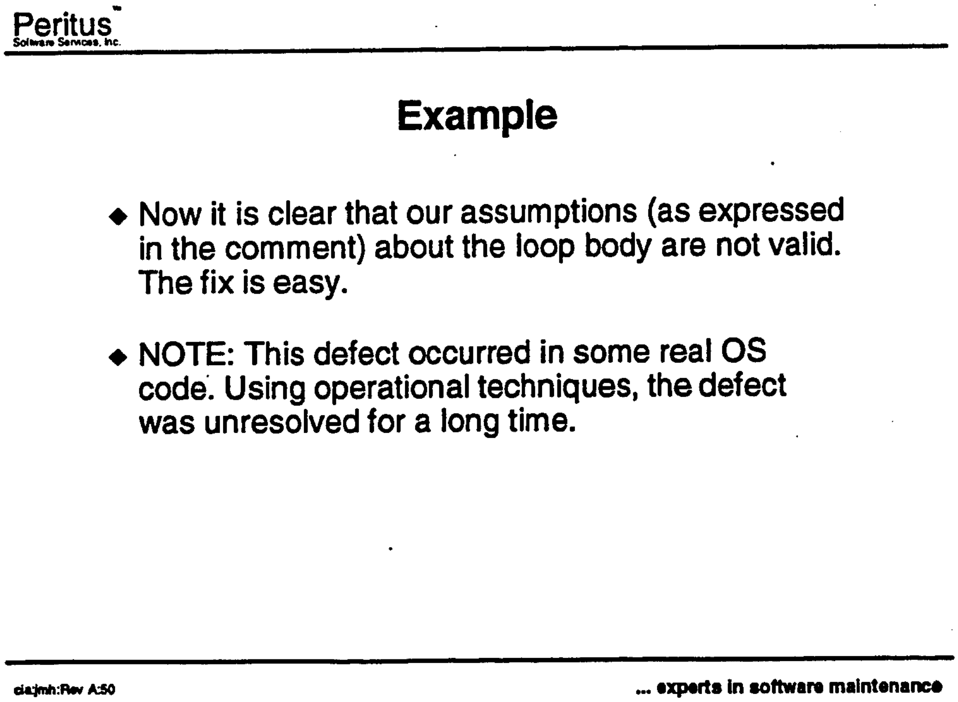

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Example

- Now it is clear that our assumptions (as expressed in the comment) about the loop body are not valid. The fix is easy.
- NOTE: This defect occurred in some real OS code. Using operational techniques, the defect was unresolved for a long time.

cia:jmh:Rev A:50

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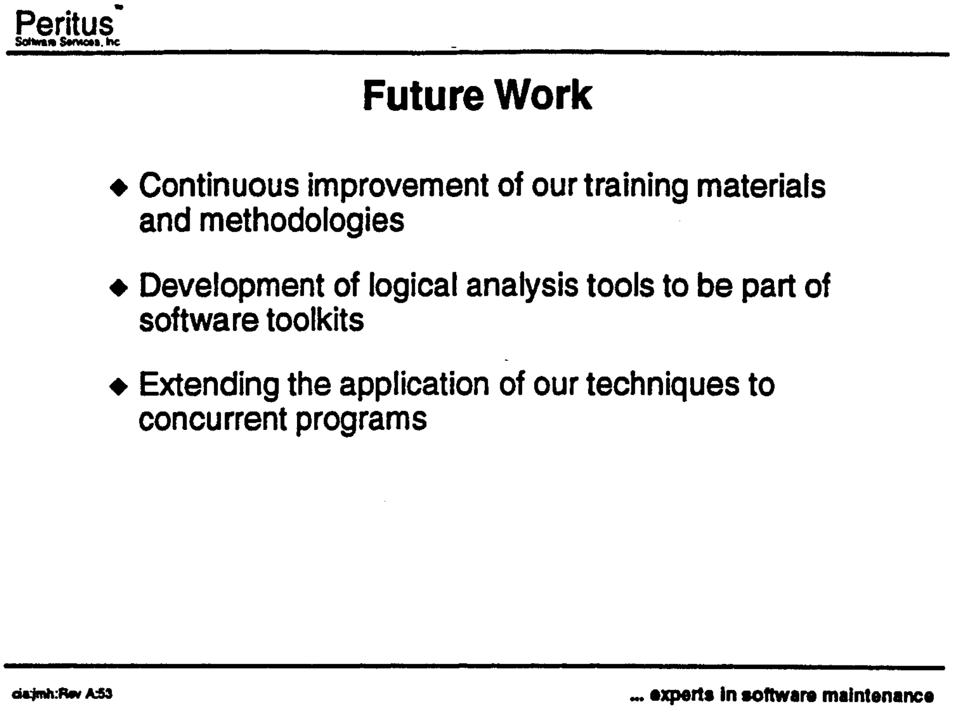

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Future Work

- Continuous improvement of our training materials and methodologies
- Development of logical analysis tools to be part of software toolkits
- Extending the application of our techniques to concurrent programs

cia:jmh:Rev A:53

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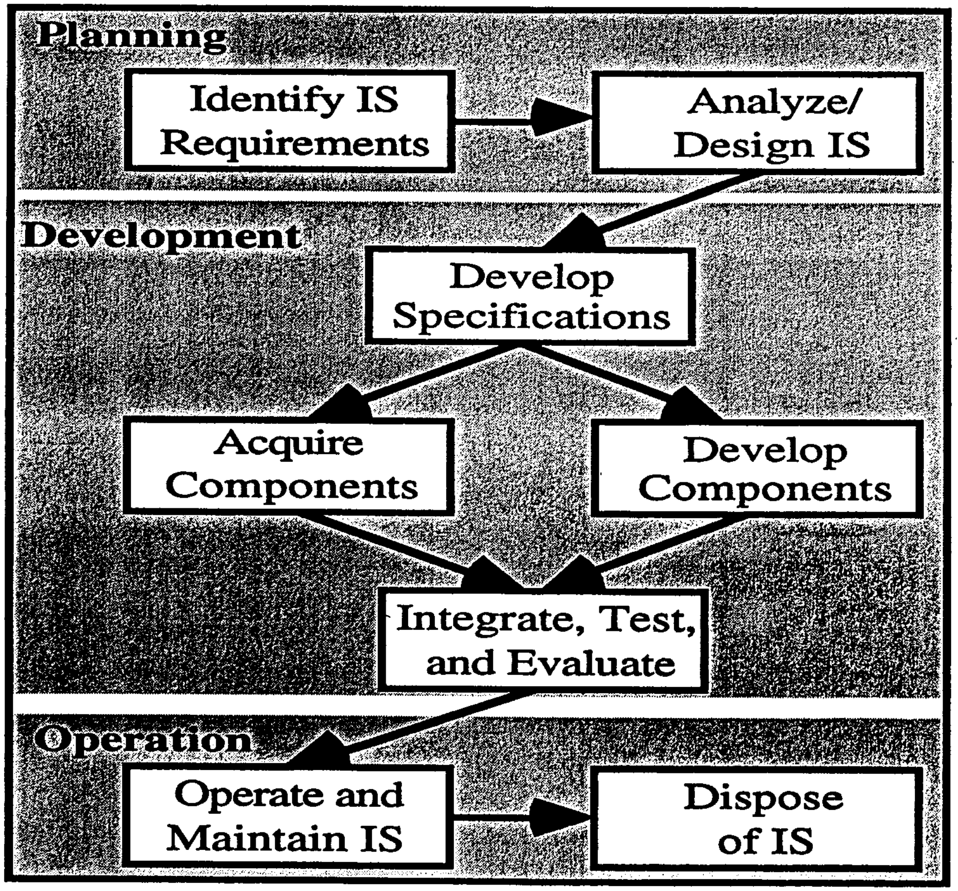
Page 27

From Business Reengineering to Information Systems

Clem McGowan

5 December 1995

Standard Information System Engineering (ISE) Process



IS = Information Systems

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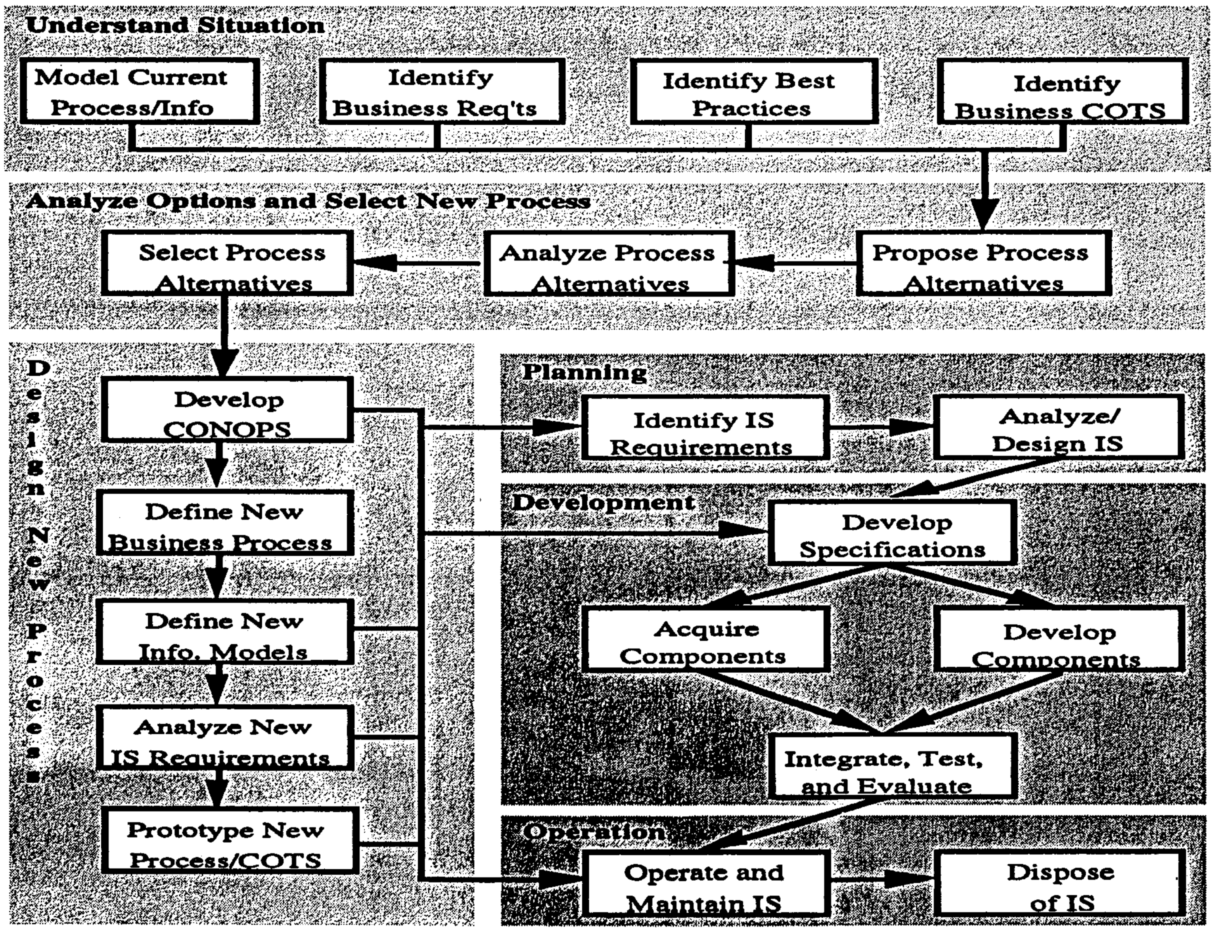
Mapping BPR Results to ISE Process



Understand Situation

Model Current Process/Info

Identify Business Req'ts

Identify Best Practices

Identify Business COTS

Analyze Options and Select New Process

Propose Process Alternatives

Analyze Process Alternatives

Select Process Alternatives

Design New Process

Develop CONOPS

Define New Business Process

Define New Info. Models

Analyze New IS Requirements

Prototype New Process/COTS

Planning

Identify IS Requirements

Analyze/ Design IS

Development

Develop Specifications

Acquire Components

Develop Components

Integrate, Test, and Evaluate

Operation

Operate and Maintain IS

Dispose of IS

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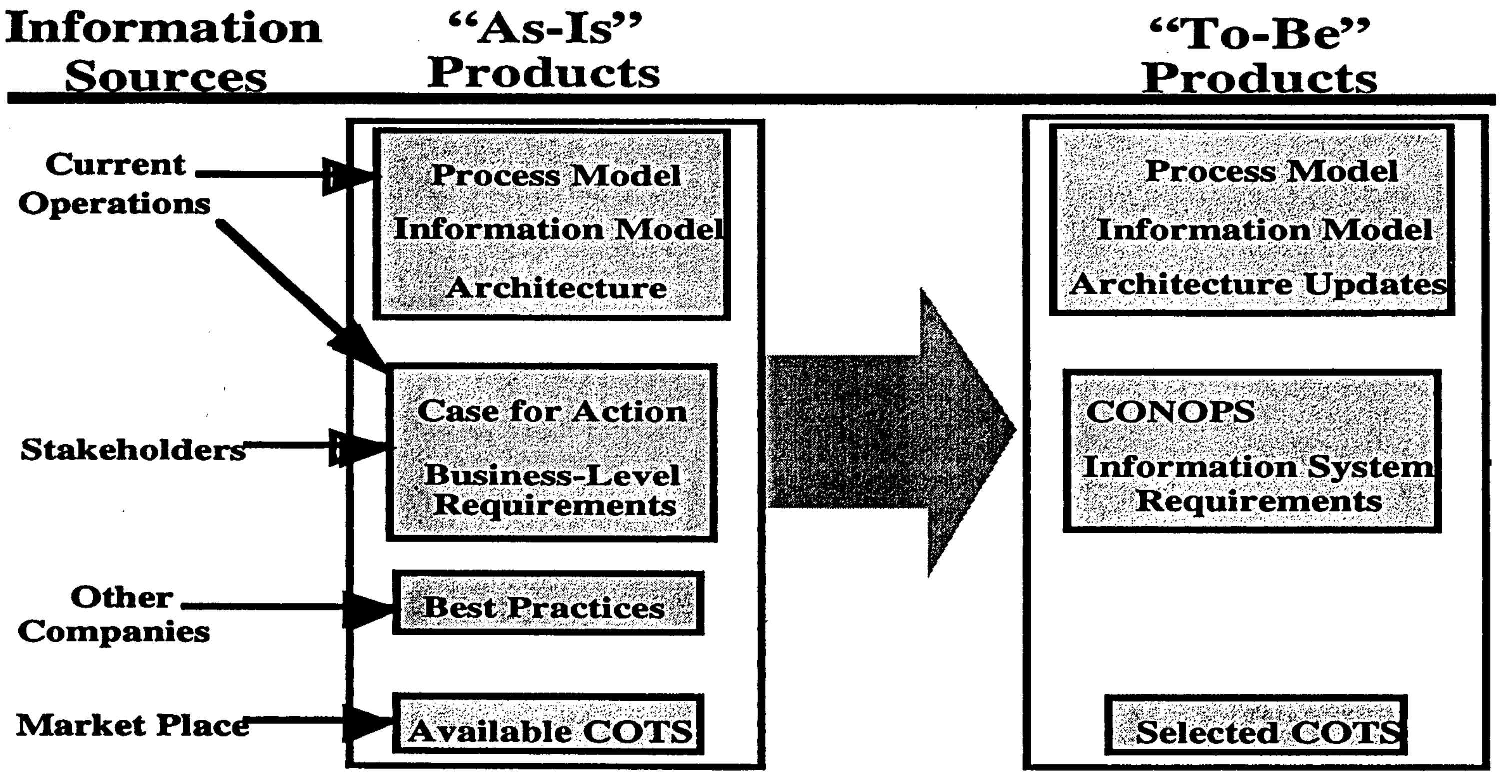
BPR Products



Important Supporting Information: Process Alternatives, Customer Satisfaction Data, Measures of Merit, Estimates of Improved Performance and Impact on Stakeholders, Prototype Results, Issues (Problems, Deficiencies, Opportunities)

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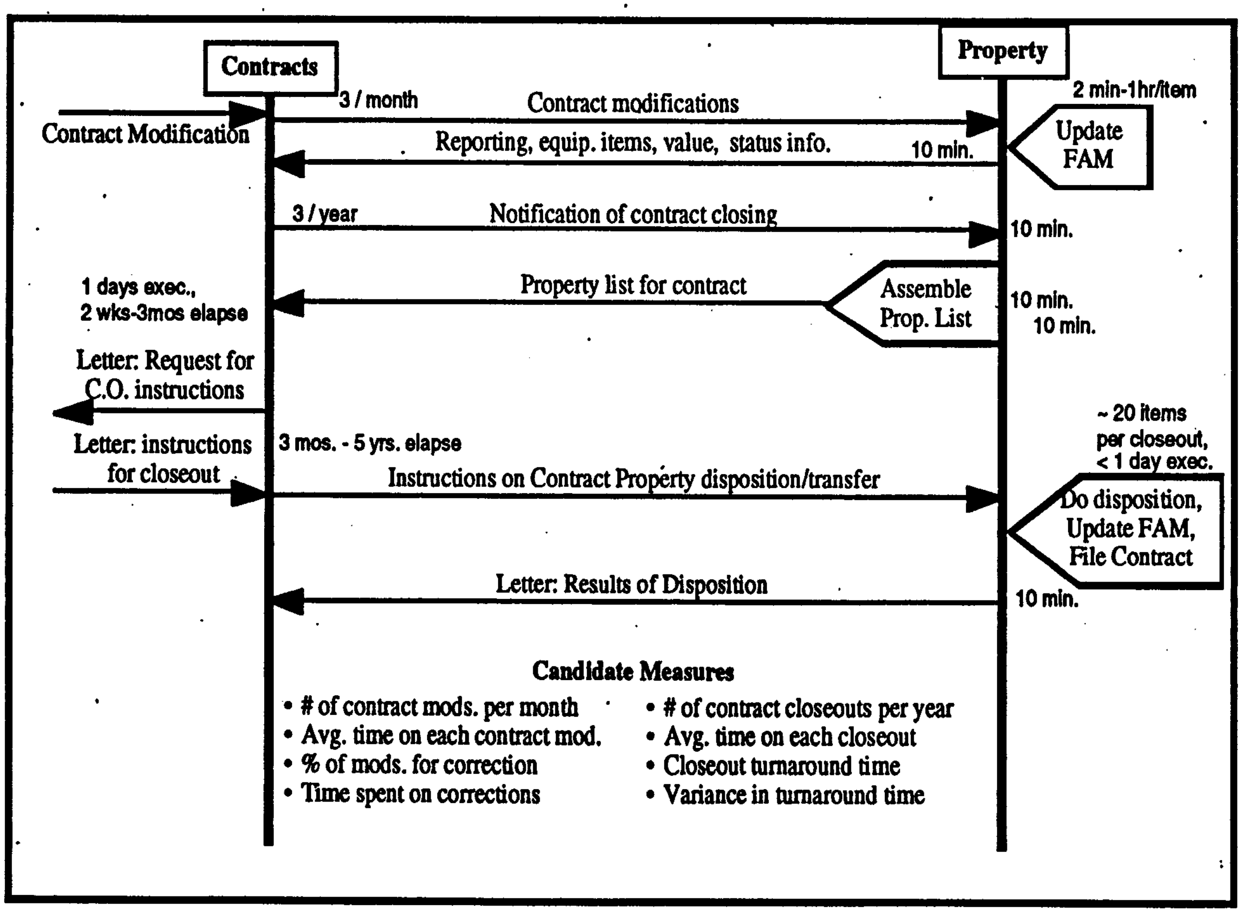
Interaction Diagram


Contracts
Property
Contract Modification
3 / month
Contract modifications
2 min-1hr/item
Update FAM
Reporting, equip. items, value, status info.
10 min.
3 / year
Notification of contract closing
10 min.
1 days exec.,
2 wks-3mos elapse
Property list for contract
Assemble Prop. List
10 min.
10 min.
Letter: Request for C.O. instructions
Letter: instructions for closeout
3 mos. - 5 yrs. elapse
Instructions on Contract Property disposition/transfer
~ 20 items per closeout, < 1 day exec.
Do disposition, Update FAM, File Contract
Letter: Results of Disposition
10 min.

Candidate Measures

- # of contract mods. per month
- Avg. time on each contract mod.
- % of mods. for correction
- Time spent on corrections

- # of contract closeouts per year
- Avg. time on each closeout
- Closeout turnaround time
- Variance in turnaround time

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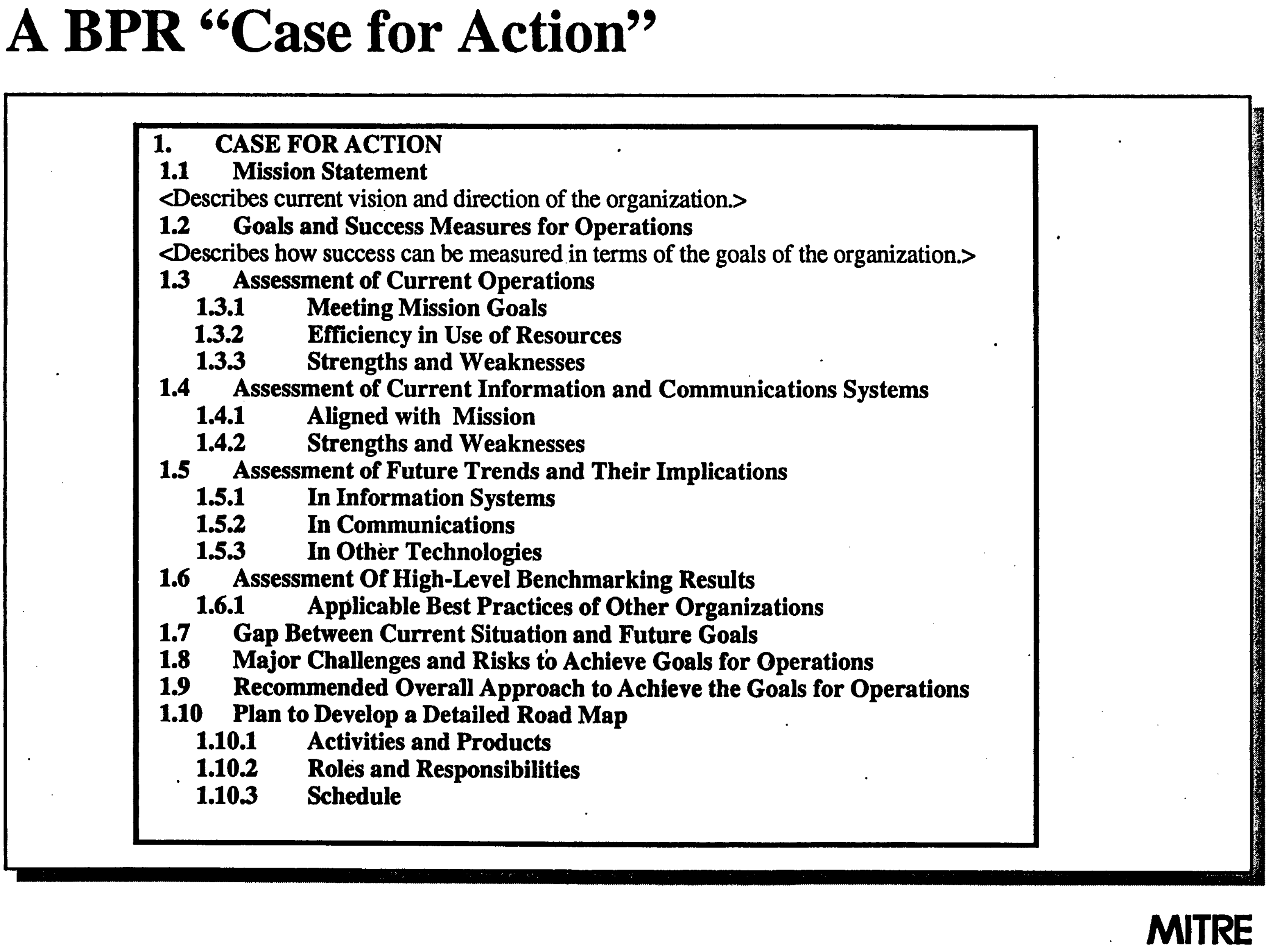

A BPR "Case for Action"

1. CASE FOR ACTION
1.1 Mission Statement
<Describes current vision and direction of the organization.>
1.2 Goals and Success Measures for Operations
<Describes how success can be measured in terms of the goals of the organization.>
1.3 Assessment of Current Operations
  1.3.1 Meeting Mission Goals
  1.3.2 Efficiency in Use of Resources
  1.3.3 Strengths and Weaknesses
1.4 Assessment of Current Information and Communications Systems
  1.4.1 Aligned with Mission
  1.4.2 Strengths and Weaknesses
1.5 Assessment of Future Trends and Their Implications
  1.5.1 In Information Systems
  1.5.2 In Communications
  1.5.3 In Other Technologies
1.6 Assessment Of High-Level Benchmarking Results
  1.6.1 Applicable Best Practices of Other Organizations
1.7 Gap Between Current Situation and Future Goals
1.8 Major Challenges and Risks to Achieve Goals for Operations
1.9 Recommended Overall Approach to Achieve the Goals for Operations
1.10 Plan to Develop a Detailed Road Map
  1.10.1 Activities and Products
  1.10.2 Roles and Responsibilities
  1.10.3 Schedule

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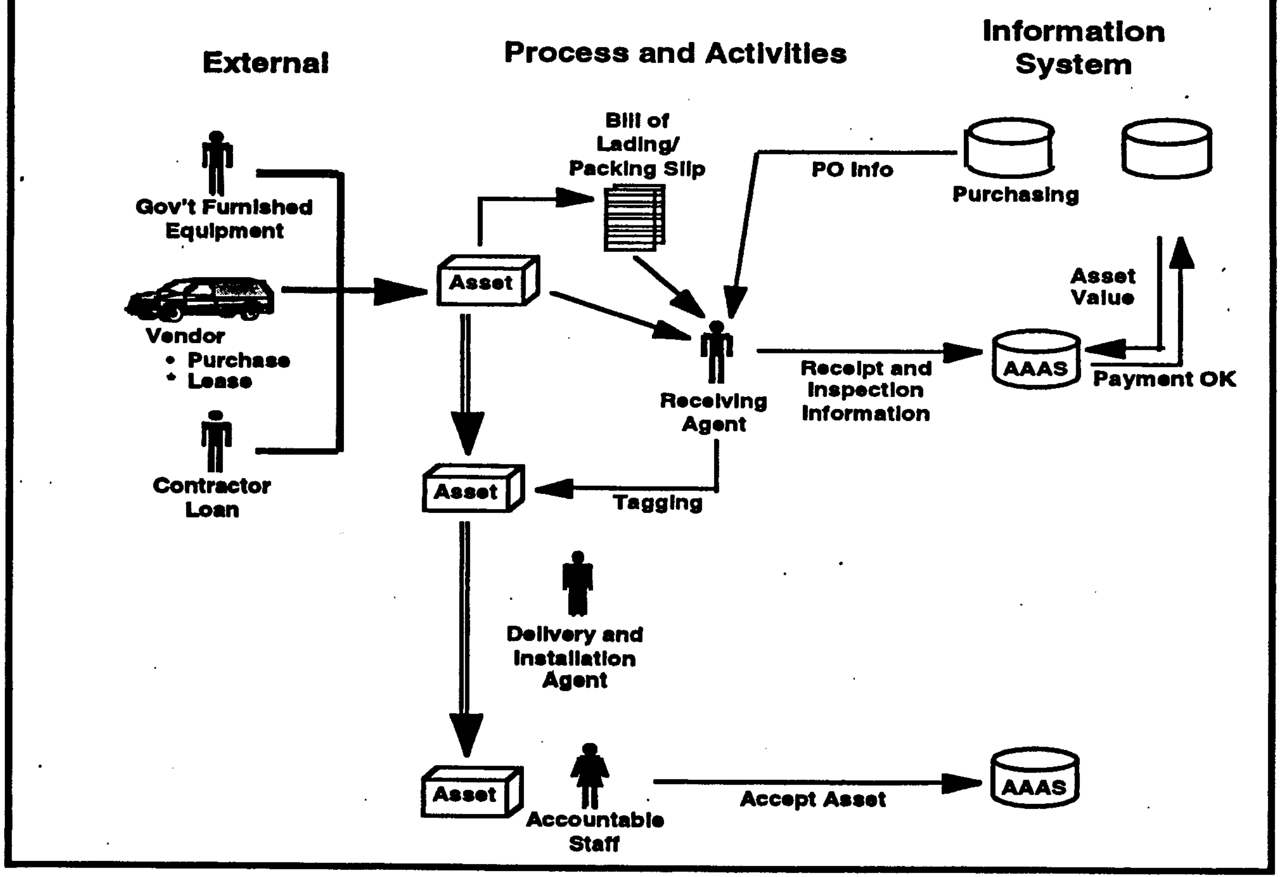
Concept of Operations (high level example)

Receiving and Delivery



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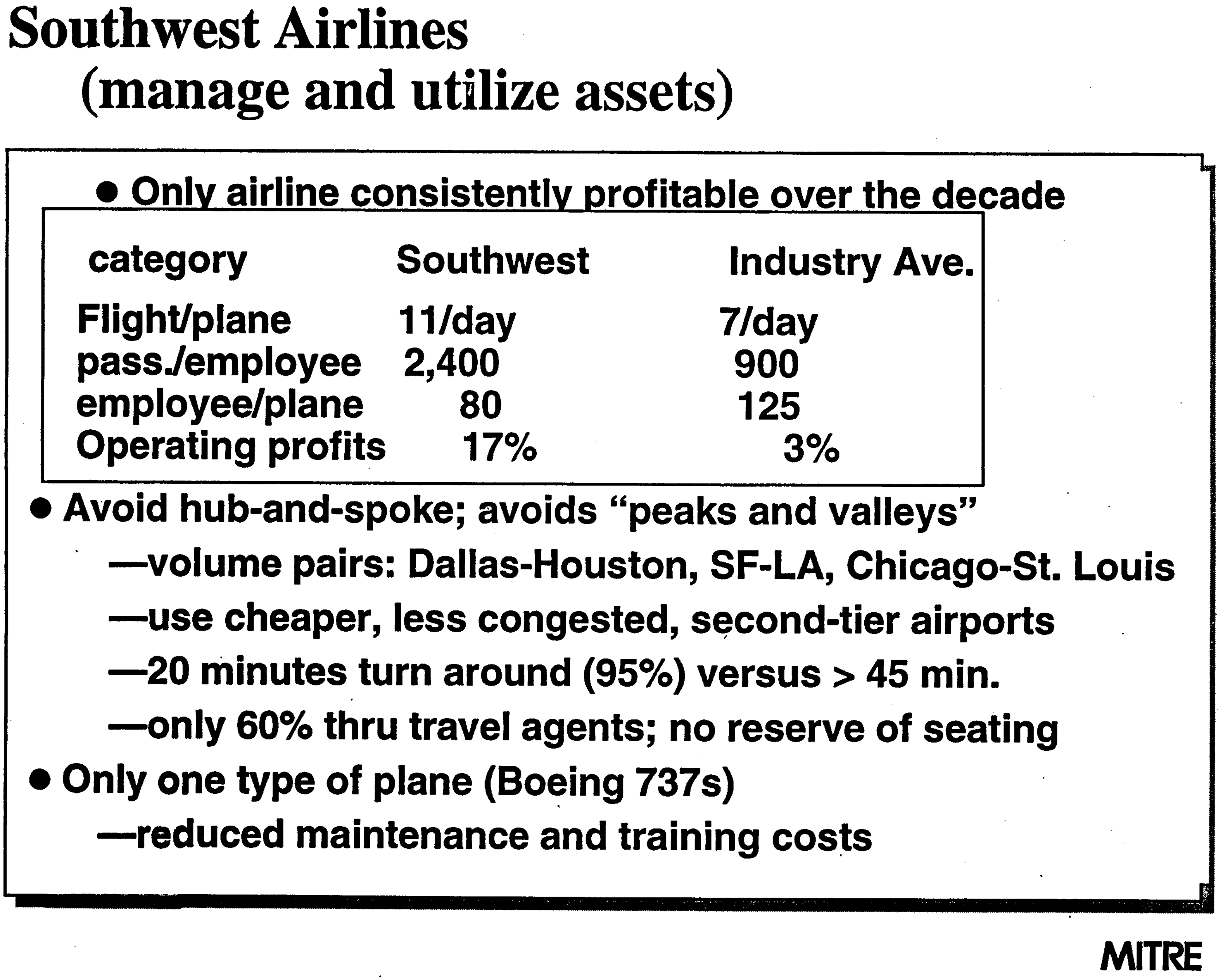

Southwest Airlines
(manage and utilize assets)

- Only airline consistently profitable over the decade

category	Southwest	Industry Ave.
Flight/plane	11/day	7/day
pass./employee	2,400	900
employee/plane	80	125
Operating profits	17%	3%

- Avoid hub-and-spoke; avoids “peaks and valleys”
  - —volume pairs: Dallas-Houston, SF-LA, Chicago-St. Louis
  - —use cheaper, less congested, second-tier airports
  - —20 minutes turn around (95%) versus > 45 min.
  - —only 60% thru travel agents; no reserve of seating
- Only one type of plane (Boeing 737s)
  - —reduced maintenance and training costs

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10

Measures/Success Indicators to Inspire Creativity in Reengineering

New Process Goals	Some Indicators of Success (Measures of Merit)	Candidate Process and Policy changes to improve performance with respect to these indicators
Completeness of Accountable Asset Coverage	• % correct in regular, internal audits • % correct and time to complete formal audits • confidence of sponsors and of management in asset system	— conduct rolling internal audits to assess — make individuals accountable for assets and responsible for maintaining asset status in AAAS — regular discussions with sponsors and management (reporting on status of asset management action list)

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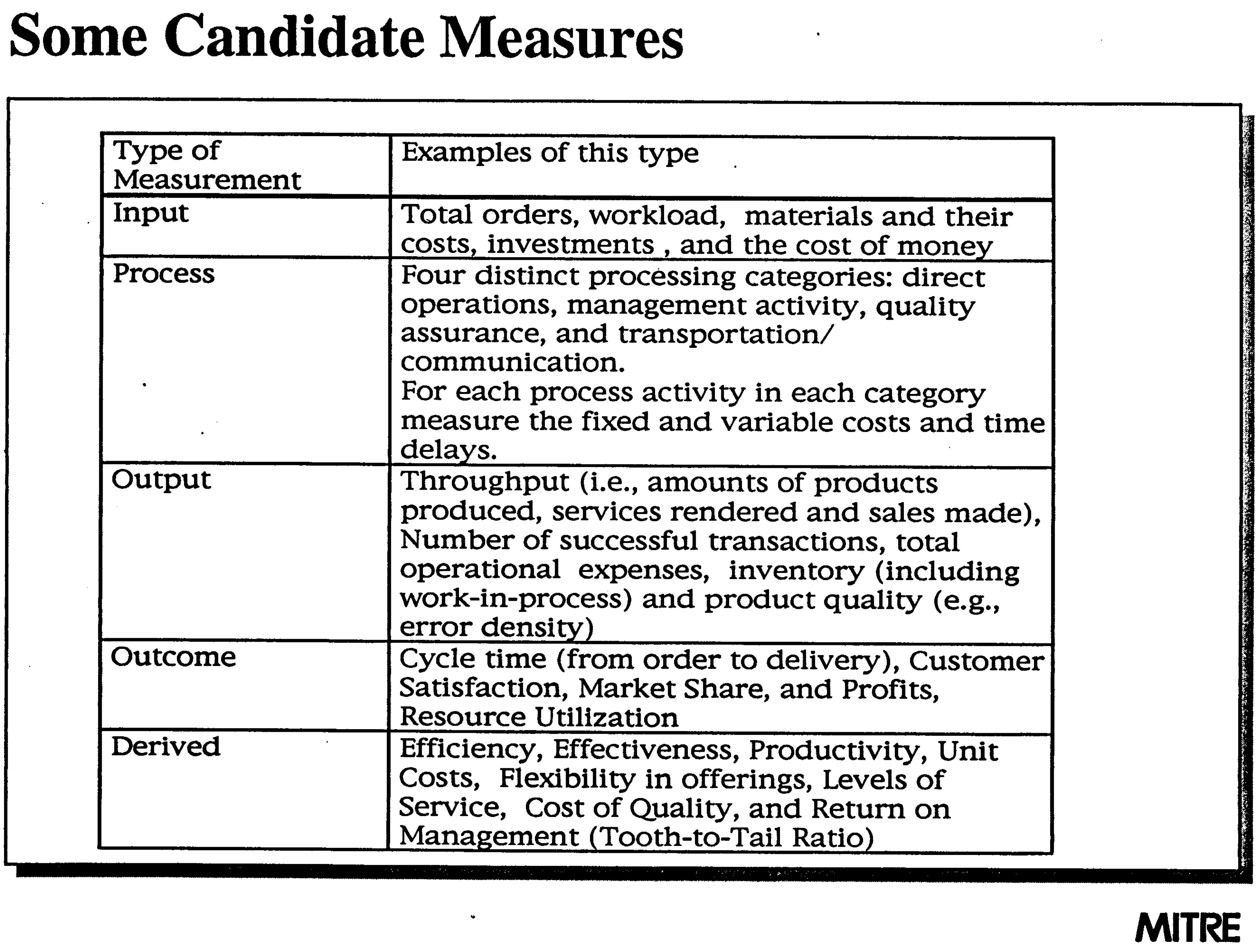

Some Candidate Measures

Type of Measurement	Examples of this type
Input	Total orders, workload, materials and their costs, investments , and the cost of money
Process	Four distinct processing categories: direct operations, management activity, quality assurance, and transportation/ communication. For each process activity in each category measure the fixed and variable costs and time delays.
Output	Throughput (i.e., amounts of products produced, services rendered and sales made), Number of successful transactions, total operational expenses, inventory (including work-in-process) and product quality (e.g., error density)
Outcome	Cycle time (from order to delivery), Customer Satisfaction, Market Share, and Profits, Resource Utilization
Derived	Efficiency, Effectiveness, Productivity, Unit Costs, Flexibility in offerings, Levels of Service, Cost of Quality, and Return on Management (Tooth-to-Tail Ratio)

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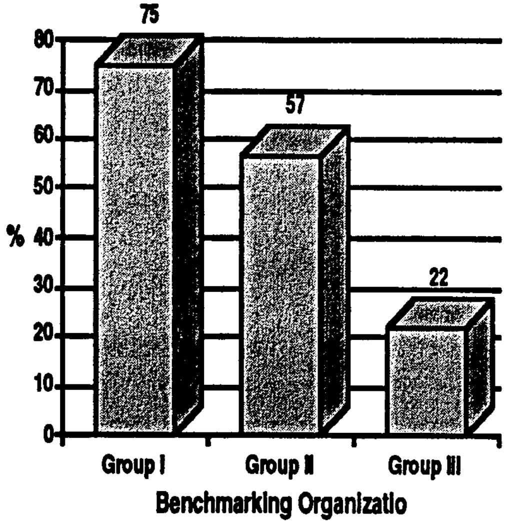
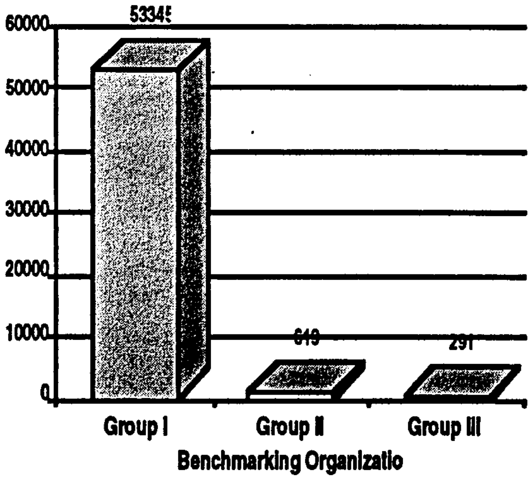
Benchmarking (at high process level) Suggests New Process Possibilities

Percent Analysis Tin



Average Products Per Analyst Per \



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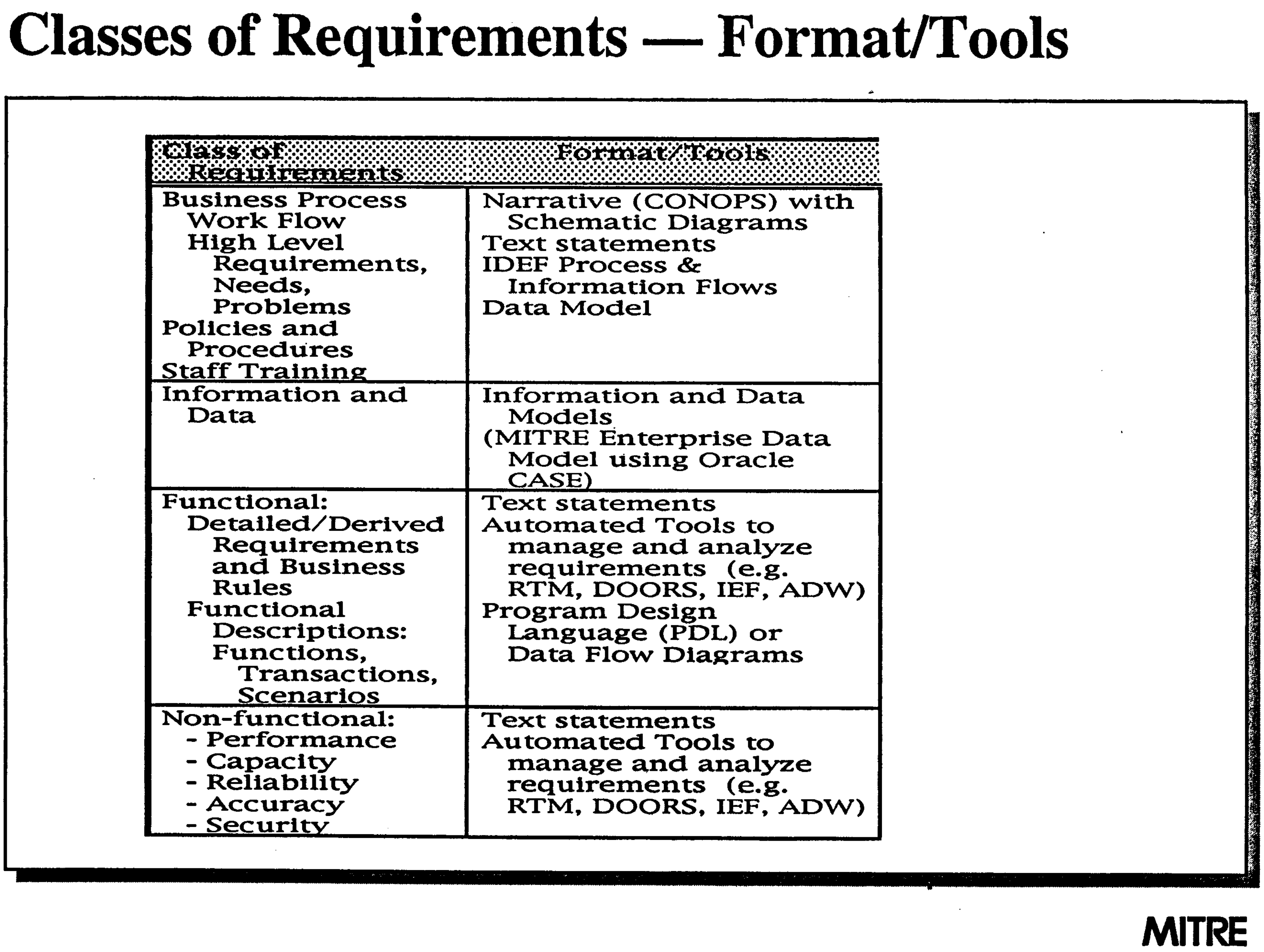

Classes of Requirements — Format/Tools

Class of Requirements	Format/Tools
Business Process Work Flow High Level Requirements, Needs, Problems Policies and Procedures Staff Training	Narrative (CONOPS) with Schematic Diagrams Text statements IDEF Process & Information Flows Data Model
Information and Data	Information and Data Models (MITRE Enterprise Data Model using Oracle CASE)
Functional: Detailed/Derived Requirements and Business Rules Functional Descriptions: Functions, Transactions, Scenarios	Text statements Automated Tools to manage and analyze requirements (e.g. RTM, DOORS, IEF, ADW) Program Design Language (PDL) or Data Flow Diagrams
Non-functional: - Performance - Capacity - Reliability - Accuracy - Security	Text statements Automated Tools to manage and analyze requirements (e.g. RTM, DOORS, IEF, ADW)

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14

Determine How Changes Will "disturb" Different Classes of Stakeholders

User Class	Change to System	Differences	Possible Resistance
Employee	•Assigned individual responsibility for assets. •Changes in asset status entered into System by responsible employee.	•Responsible employee accepts and relinquishes responsibility of assets in a controlled manner.	•Employees will feel additional burden of asset responsibility. They may require more security control on their assigned assets (see security). •Employees will need to be trained on new asset movement, transfer, and disposal procedures (training material may be on-line). ...

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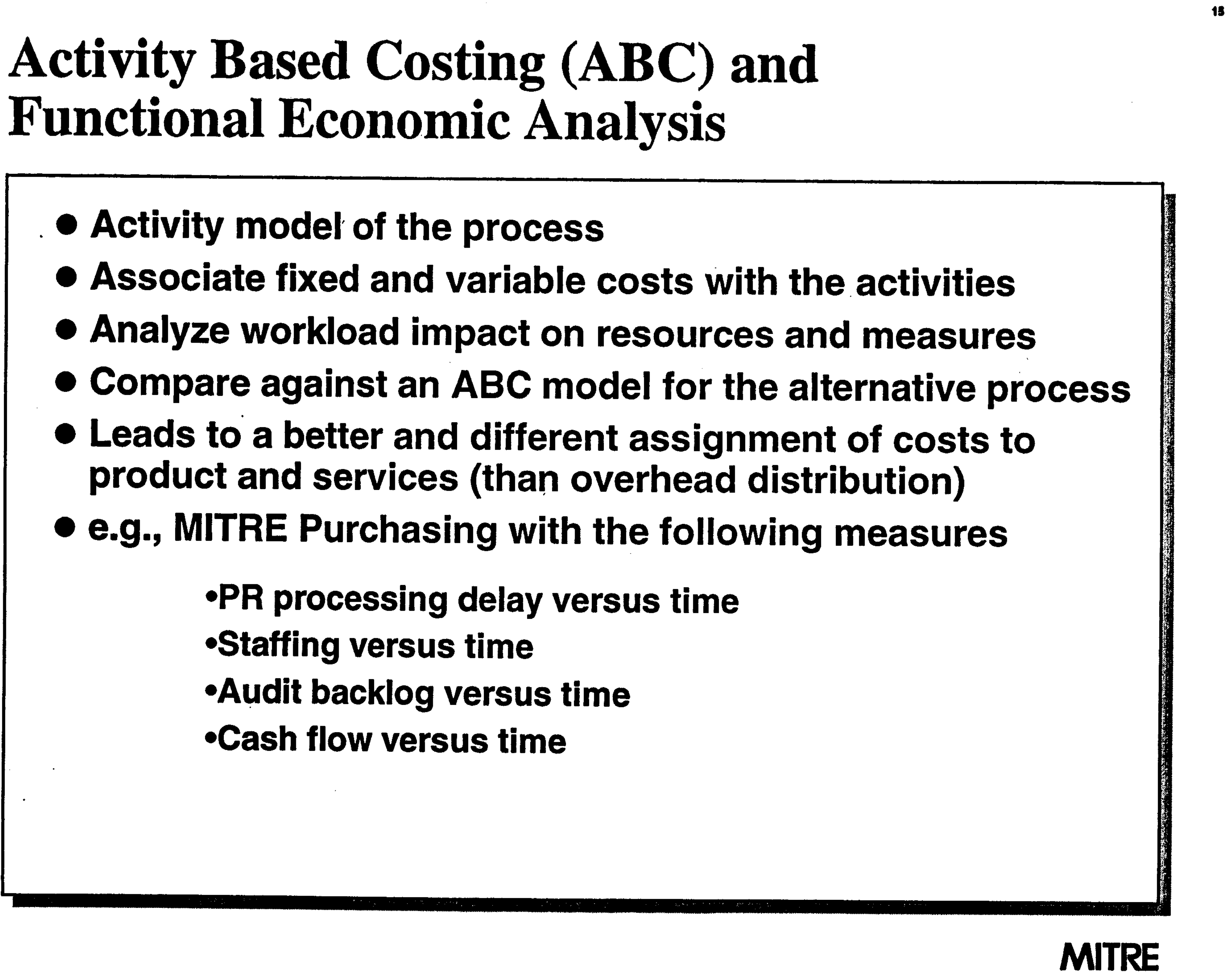

15

Activity Based Costing (ABC) and Functional Economic Analysis

- Activity model of the process
- Associate fixed and variable costs with the activities
- Analyze workload impact on resources and measures
- Compare against an ABC model for the alternative process
- Leads to a better and different assignment of costs to product and services (than overhead distribution)
- e.g., MITRE Purchasing with the following measures
  - PR processing delay versus time
  - Staffing versus time
  - Audit backlog versus time
  - Cash flow versus time

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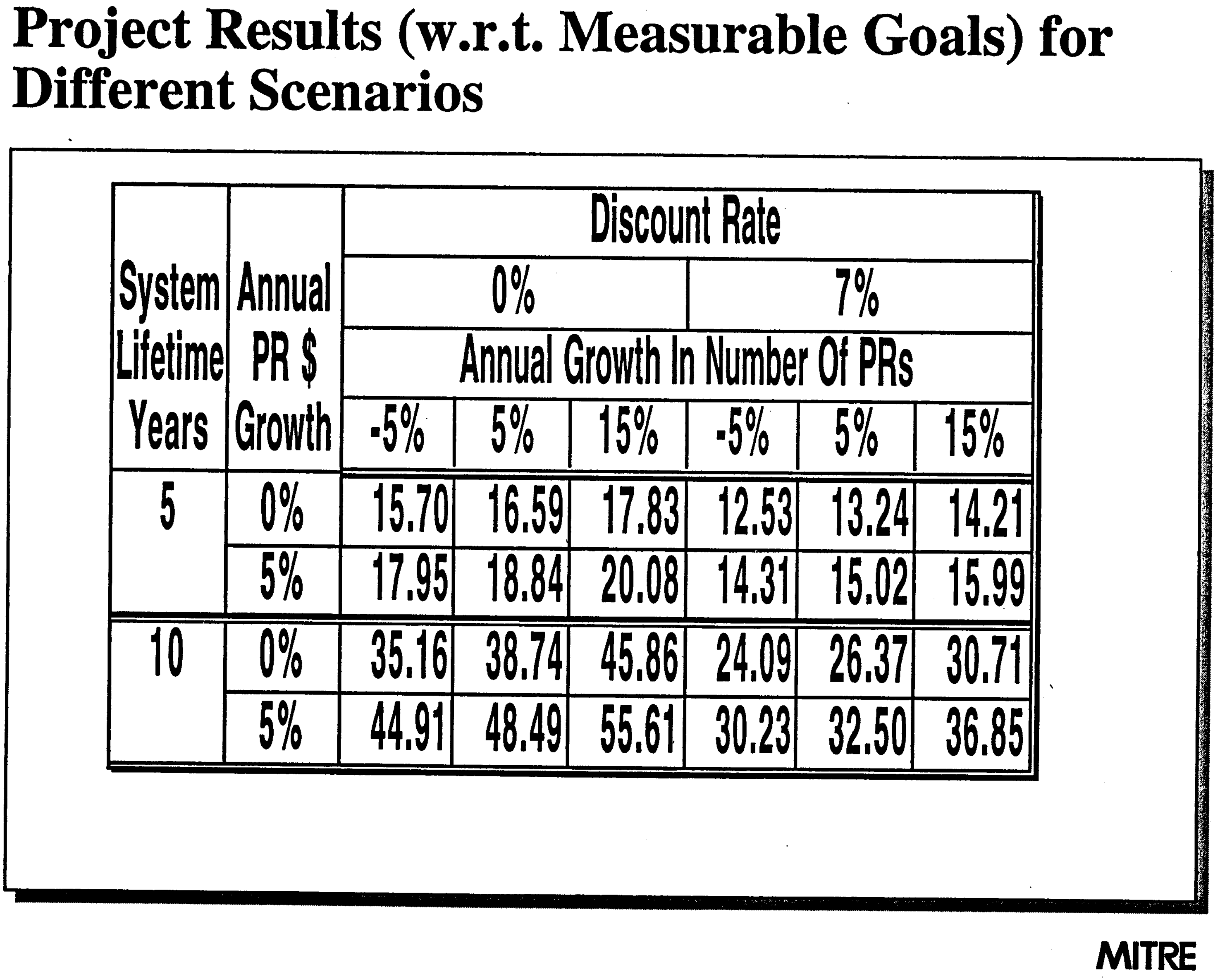

Project Results (w.r.t. Measurable Goals) for Different Scenarios

System Lifetime Years	Annual PR $ Growth	Discount Rate					
		0%			7%		
		Annual Growth In Number Of PRs					
		-5%	5%	15%	-5%	5%	15%
5	0%	15.70	16.59	17.83	12.53	13.24	14.21
	5%	17.95	18.84	20.08	14.31	15.02	15.99
10	0%	35.16	38.74	45.86	24.09	26.37	30.71
	5%	44.91	48.49	55.61	30.23	32.50	36.85

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Managing a BPR-to-IS Requirements Project

BPR Activity / WBS Task	Work Units
A0 – Reengineer Business	1000
A1 – Manage Process Reengineering Effort	150
A11 – Produce and Approve BPR Project Plan	20
A12 – Build and Direct BPR Team	30
A121 – Establish BPR Team Requirements	8
A122 – Identify BPR Expertise	3
A123 – Identify Business Domain Expertise	3
A124 – Identify Information System Expertise	3
A125 – Identify Candidate Project Leaders	3
A126 – Acquire Team Member Resources	10
A13 – Get Buy-in from Process Stakeholders	40
A131 – Determine Key Business Process to Reengineer	5

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More Project Activities [≈ 20% resources to understand current process]

A2 - Understand Current Business Process Situation	200
A21 - Interview Stakeholders	50
A211 - Schedule Interviews with Key Process Stakeholders	5
A212 - Assemble Material for Interviews	5
A213 - Conduct Interviews with Stakeholders	25
A214 - Organize Notes from Interviews	15
A22 - Capture Business Level Requirements	40
A221 - Analyze Existing Requirements	15
A222 - Review Stakeholder Interview Notes	5
A223 - Identify New Requirements	10
A224 - Record Business Requirements	10
A23 - Identify "Best Practices"	30

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Different Expertise Needed in Different Stages of a Project

Expertise/Knowledge	Activities	Description
Domain Organization	A13, A15, A21, A41	Knowledge of organizational structure, key decision-makers, process stakeholders (and interfaces between them), and organizational policies and procedures.
Business Process	A25, A32, A33, A41, A42	Can describe and evaluate performance of key business processes of the organization. Identifies resources, customer interfaces, responsibilities, and constraints.
Best Practice	A23, A32	Knowledge of current best practices in the application domain. Contacts in competing or similar businesses.
Business Information	A25, A42	Understanding of information produced by the business process and information needed to run the business.
Business COTS	A24, A31, A32, A45	Knowledge of commercial-off-the-shelf software applications used in the business domain.
Business Operations	A25, A41	Experience in business areas where process is applied as well as interactions with related business areas.

4. RESULTS

At the end of the workshop, each participant was asked to list the topics that interested her or him. The topics were collected and presented to the participants. Each participant was then asked to vote on the three topics that most interested her or him. The following table lists the topics and the number of votes assigned to each topic.

Topic	Number of Votes	Topic	Number of Votes
Potholes and Pitfalls of Reengineering	3	Code Translation	3
Tools Experience	9	User Interface Reengineering	6
BPR and Software Engineering Relationship	6	Metrics	3
Systems Reengineering	8	"Wrapped" Legacy System Reengineering	0
Transition Planning	11	Product Lines	4
COTS	9	How Much	2
Planning	13	Methods—OO	3
Methods—CS	3	Reengineering Cost/Benefit Analysis	14

Furthermore, the following World Wide Web sites were identified as useful sources of reengineering information:

- www.afmc.wpafb.af.mil
- www.reengineer.org/forum
- www.sei.cmu.edu/~reengineering
- www.softwre.org

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APPENDIX A. WORKSHOP ATTENDEES

The following is an alphabetical list of all attendees of the Second Software Productivity Consortium Reengineering Workshop.

Name	Organization	Address
Aiken, Peter	Virginia Commonwealth University	(804) 828-0174 paiken@caball.vcu.edu
Bohan, Jennifer	Vitro Corporation	(703) 418-8275 bohanj@vitro.com
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Clark, John	Comptek Federal Systems, Inc. Va. Beach Engineering Services	(804) 463-8500 x316 clark@comptek.com
Davis, Ted	Software Productivity Consortium Reuse & Reengineering Project	(703) 742-7335 davis@software.org
Evers, Ed	CACI CACI Advanced Technology Center	(703) 841-7838 eevers@hq.caci.com
Facemire, Jeff	Software Productivity Consortium Reuse & Reengineering Project	(703) 742-7189 facemire@software.org
Fee, Sandra J.	Vitro Corporation Software Center of Excellence	(301) 231-1403 fee@vitro.com
Feerrar, Caterine M.	Vitro Corporation AUA-11	(301) 738-5314 feerrar@vitro.com
Gerritsen, Douglas	U. S. Army Armaments R&D Center	(201) 724-3587 dgerrit@pica.army.mil
Gracza, John W.	CASE Associates, Inc.	(703) 978-7120 cai@teleport.com
Graves, Robert	Vitro Corporation Advanced Software Technology	(301) 231-3126 gravesr@vitro.com

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Phisterer, Cathy	CACI IT Company - Federal	(703) 277-6768 cphisterere@std.caci.com
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Sharon, David	CASE Associates, Inc.	(503) 656-0986 cai@teleport.com
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Sutherland, David	Lockheed Martin Corporation Information Systems Company	(407) 826-7956
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APPENDIX B. WORKSHOP AGENDA

The following is the final agenda of the Second Software Productivity Consortium Reengineering Workshop.

MONDAY, DECEMBER 4, 1995

8:15 - 8:35	Welcome and Introduction	J. Facemire, the Software Productivity Consortium
8:35 - 9:15	The IS Reengineering Spectrum: Terms, Approaches, Methods, Tools	E. Chikofsky, DMR Group
9:15 - 9:25	Software Productivity Consortium	A. Pyster, the Software Productivity Consortium
9:25 - 10:10	SPC's Product-Line Approach	J. Facemire, the Software Productivity Consortium
10:10 - 10:25	Break	
10:25 - 11:55	IS Reengineering Experience Reports - Internal Revenue Service - Integrating Domain Engr. and Reengr. - Others - Discussion	E. Chikofsky, DMR Group (moderator) J. McCreary, IRS N. Prywes, CCCC/U Pa
11:55 - 12:25	Reengineering of User Interfaces - UI Reengineering at Maryland	J. Facemire, the Software Productivity Consortium (moderator) A. Rose, Univ. of Maryland
12:25 - 1:25	Lunch	
1:25 - 2:40	Data Reengineering - Focus: Data Reengineering - Discussion	E. Chikofsky, DMR Group (moderator) P. Aiken, VA Commw U
2:40 - 2:55	Break	
2:55 - 3:55	Reengineering Economics - Software Reengr. Assessment Handbook - Discussion	J. Facemire, the Software Productivity Consortium (moderator) J. Clark, Comptek
3:55 - 4:25	Tools for Reengineering - Classifying Tools for Reengineering State of the Industry	E. Chikofsky, DMR Group (moderator) D. Sharon, CASE Assoc.
4:25 - 5:00	What We Heard: Summary Discussion of the Day (all attendees)	J. Facemire, the Software Productivity Consortium E. Chikofsky, DMR Group

TUESDAY, DECEMBER 5, 1995

8:15 - 9:15	Object Technology in Reengineering	M. Blackburn, the Software Productivity Consortium (moderator)
	- Enterprise Solutions with Objects (demo)	R. Maroney, Template SW
	- Discussion	
9:15 - 10:30	Reverse Engineering	E. Chikofsky, DMR Group (moderator)
	- Framework for Progr. Understanding	S. Tilley, SEI
	- Rev Engr. Code into Requirements (include Logical Code Analysis)	M. Blackburn, the Software Productivity Consortium
	- Discussion	J. Hart, Peritus
10:30 - 10:45	Break	
10:45 - 12:00	Reengineering Information Systems	A. Kromholz, the Software Productivity Consortium (moderator)
	- Recap: SPC's Product Line Approach	J. Facemire, the Software Productivity Consortium
12:00 - 1:45	Reengineering Information Systems	A. Kromholz, the Software Productivity Consortium (moderator)
	- Bridging Gap Betw BPR and SW Syst.	C. McGowan, MITRE
	- Discussion	
1:45 - 2:45	What We Heard and What We Need Summary Disc. and Prioritization	J. Facemire, the Software Productivity Consortium E. Chikofsky, DMR Group
2:45 - 3:00	Closing Remarks/Adjourn	J. Facemire, the Software Productivity Consortium